SOCIETAL RISKS OF ENERGY SYSTEMS

HEARING

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

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SOCIETAL RISKS OF ENERGY SYSTEMS

THURSDAY, JUNE 18, 1981

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C.

The committee met at 2:15 p.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the committee) presiding.

Mr. FUQUA. The committee will be in order.

This afternoon, the full Committee on Science and Technology meets to hold a hearing on a subject of extreme importance to all of our members, namely, societal risks associated with energy production and end use.

This committee can be proud of its record of informing Congress about the leading technical risk and safety issues and in developing legislation to improve the Federal Government's ability to deal more systematically with risk management.

For example, following the Three Mile Island accident, our Subcommittee on Energy Research and Production held comprehensive hearings on nuclear powerplant safety systems and on low-level radiation. These hearings led, in part, to the enactment of Public Law 96-567, the Nuclear Safety Research, Development and Demonstration Act, which directs the Department of Energy to assess risk factors and develop cost-beneficial changes in powerplant design and operation.

Also during the 96th Congress, our Subcommittee on Science, Research, and Technology held extensive hearings and forums on comparative risk assessment and risk benefit analysis. The subcommittee also considered Congressman Ritter's bill to establish a coordinated program for the use of risk analysis in all Federal agencies that make decisions affecting health and safety. Congressman Ritter has reintroduced his risk bill in the 97th Congress and it is likely to be taken up again by the subcommittee.

Our Subcommittee on Natural Resources Agriculture Research and Environment continually reviews health and environmental risk issues as part of its environmental R. & D. jurisdiction.

It is important for the committee to continue its good work on risk policy, particularly in the energy area, where the Nation is embarking on new programs for energy development, while at the same time reviewing and reforming the regulatory process.

There continues to be a substantial amount of public criticism of the present approach to Federal risk management. On the one hand, there are those who say we are not doing enough to control what they see as excessive energy health and safety risks.

Then, on the other side, there are those who claim that the current approach has produced excessive regulation aimed at reducing, still further, relatively small risks, and that this lowers productivity and inhibits energy development.

Whichever point of view you take, one thing seems certain—we apparently need a more consistent, more structured system for risk management. Sometimes Congress is to blame for enacting legislation which is either too vague or too prescriptive. Sometimes the regulatory agencies are at fault for promulgating rules and regulations which are not based on adequate analysis. Ultimately, litigation brings these issues before the judicial system, which in many cases does not have the expertise to properly evaluate the issues.

The assessment of risk is obviously a key element in the formulation of energy policy. In today's hearing, we shall examine the major risk issues in energy and how risk analysis methods can help us better understand the choices before us.

Our first witness today is Congressman Don Ritter of Pennsylvania, a Ph. D. scientist in his own right, and a former member of our committee. Don has been one of the leading people in the Congress to promote a more systematic and rational approach to Federal risk management.

After Congressman Ritter, we will hear from a panel of energy risk experts: Dr. Lester Lave of the Brookings Institution; Dr. William Ramsay of Resources for the Future; and Dr. Chester Richmond of Oak Ridge National Laboratory.

I would like to ask unanimous consent that photographic and recording devices be used during the period of the hearing.

Is there any objection? The chair hears none, so ordered.

I recognize the gentleman from Kansas, Mr. Winn.

Mr. WINN. Thank you, Mr. Chairman, for this opportunity to welcome our witnesses today.

If my memory is correct this is the fourth hearing sponsored by our Committee on Risk Assessment or Risk Analysis in a 6-year span. We look forward to hearing about the progress being made toward the useful application of these decisionmaking procedures and how that progress is measured.

It is hoped that the newly formed Society for Risk Analysis realizes that many difficult tasks lie ahead. It would seem to me that you must work within certain guidelines. Analysis should be prepared by groups or panels to minimize personal subjective biases. Since we cannot establish the value of a life or an injury, risk should be analyzed by comparison.

One past witness has stated that risk assessments are useful only if they are not taken too seriously. They are only a few of the input points for a reasonable solution.

Your society must instruct users in the proper role of risk analysis and provide guidance for public understanding of the concept. In any case, we can certainly say at this time that the process of risk analysis subjects us to the discipline of making decisions based on comprehensive surveys and evaluations. In other words, Mr. Chairman, I am saying we must look at all of the parts of this big picture. I thank you, Mr. Chairman, and yield back.

Mr. FUQUA. Mrs. Bouquard, Chairman of the Subcommittee on Energy and Research Production.

Mrs. BOUQUARD. Thank you. I would also like to extend a welcome to our witnesses today and I hope that through their clear exposition today, we can come away with a better perspective on risk analysis, its uses and its limitations.

To perform comprehensive risk assessment on any set of energy production issues is a little like asking for someone to explain the universe. The task clearly cannot be completed.

But this does not mean that one should not attempt, as best as one can, to assemble useful sets of information which may lend themselves to meaningful risk analysis.

It would be useful if our witnesses today could help us in establishing a set of criteria which should be satisfied before meaningful, quantitative risk analysis methods can and should be applied.

As many of you know, a number of issues have arisen in the past involving risk assessment of nuclear versus other energy generation technologies. In response to this, the nuclear community has been and continues to be at the forefront in risk analysis research. In fact, it has pioneered many of the presently used techniques. As the detailed data becomes available, many of these procedures will be used to identify critical risk issues related to other types of energy technologies. The final outcome of these comparative studies will be of great interest to policymakers.

Ideally, one hopes that energy policy decisions can and would be based on the considerations of factors such as risk in proportion to the probability of occurrence and importance of any anticipated effect. This is difficult to do when effects are not quantified in the same fashion. Limited data used uncritically can only lead to wrong policy decisions.

I would ask our witnesses today to try and shed some light on how we can integrate the quantitative estimates of some risks with the uncertain, intuitive estimates of other risks in a way which does not erroneously bias the outcome.

Mr. FUQUA. I would like to recognize Mr. Carney for a statement he wishes to make.

Mr. CARNEY. Thank you very much. There is just one point I would like to add to the discussion at this time. As a member of the subcommittee concerned with the environmental protection, that point concerns how risk is defined and evaluated in an environmental sense.

I realize most of our discussion will center around risks from energy production facilities, such as coal and nuclear powerplants, and how those risks should be defined, assessed, and compared. However, there are additional sources of risk in our society, other than those for energy production, for which the questions of risk definition and assessment are just as contentious, if not more so.

I am referring to matters such as the emission or disposal of hazardous chemicals and wastes and open dumping and sewage sludge. We have to know what permissible levels are for various chemicals that may be released into the environment, and what the risks are of exceeding those levels.

For example, how many parts per million of a barium should be permitted in drinking water, and what are the risks to human health at a higher level? Is it the arbitrary restriction on the use of

water supplies for the lack of knowledge of health effects an even greater risk?

Another example, and one that hits close to home for me, is the one concerning the risks to the ocean environment from dumping sewage sludge at one offshore site versus another further from land. How do we define when these risks are acceptable or not acceptable?

The problems become especially evident when returning to energy as our reference point. We try to assess the impacts of acid rain or the greenhouse effect. Compare these environmental risks to those of radioactive wastes, or the risks to society from not using the energy sources that produce these effects.

Mr. Chairman, those are some of the topics I hope our witnesses will address as we begin these hearings.

If they can increase our understanding of these complex relationships by even 10 percent, I will consider the hearings to have been very successful. Thank you for the opportunity to give an opening statement.

Mr. FUQUA. Thank you, Mr. Carney.

At this time, we would be happy to hear from you, Don, and we welcome you back to the committee that you served on very ably for 2 years.

STATEMENT OF HON. DON RITTER, REPUBLICAN, OF PENNSYLVANIA, HOUSE OF REPRESENTATIVES—FIFTEENTH CONGRESSIONAL DISTRICT

Mr. RITTER. Thank you. It is indeed a pleasure to return to the Science and Technology Committee. I have not enjoyed my absence and I am delighted to be back today.

I am really delighted to see that this committee is holding forth in a kind of unified and coordinated way approaching the subjects of really putting hazards in their proper perspective. So I congratulate you for having these hearings today, chairman and distinguished colleagues.

I join you in welcoming our guests. Since joining the U.S. Congress 2 years ago, I have continually encouraged and actively promoted the concepts of risk assessment and risk comparison.

Congressman Carney's comments are so true in comparing one risk to another. And that there is no such thing as a zero risk to society.

I am pleased to see evidence of the increasing awareness of these concepts. Recently, Secretary Schweiker of Health and Human Services voiced his strong support for an extension of the moratorium allowing saccharin on the market. In his statement, the Secretary referred to the risks and benefits of products we use and that there are few things in our society today that present a zero risk.

I am glad to see that language being used and I would like to take a little credit in that one of my key staff members now works closely with the Schweiker team.

We are here today to consider the societal risks of energy systems. All energy systems have risks associated with them and energy in our society is beyond just being a benefit; it is a need.

Let's turn to the human health and safety issue. Health effects generally mean health hazards so we need to get some idea of what is meant by hazard, what is the risk to the public, to individuals.

Putting hazards to some reasonable perspective means we at least need to try and estimate the risk of exposure. Thus, we need to try and estimate risk in a reasonable way. Risk analysis studies of energy technologies contribute to political decisions and make them more informed, even easier. They are no panacea but they may be able to bring a little more of the scientific approach than we have seen.

I hope that these hearings today will acquaint my colleagues with the kind of bipartisan approach that risk assessment attempts to provide. My own view, as a scientist, and as a Member of Congress, is that energy policy decisions are, in the final analysis, political in nature, and should be shaped by an informed public and then elected representatives; however, after witnessing the highly emotional energy debates of recent years, often mixing ideology with science, it's obvious that the quality of this debate would be increased by a little more objective scientific input. Let's face it, we are starved for better scientific input to improve our energy/environmental decisionmaking process. I think you will hear testimony today from our distinguished guests that will increase your confidence in the potential of risk analysis.

I hope these hearings help to remove some of the scientific mystique that is frequently associated with risk analysis. In my own efforts to gain support for this concept, I have found a reluctance to accept it because of a feeling that it is too complex.

It is too preliminary, not yet arrived. Risk analysis that results in some number is meaningless unless you can relate it to something, something that is known to people. I believe that an effective consideration of risk should result in a comparison of risk, including those kinds of risks taken in common, everyday experience.

Let me give you an example: When evaluating the hazard that eating eggs presents, one finds that eating one-half dozen eggs, on the average, involves one chance in a million of one death per year due to cholesterol intake. It can also be said that the consumption of six eggs is equally as hazardous as smoking 1.4 cigarettes, living 2 days in New York or Boston and being subjected to air pollution; traveling 10 miles by bicycle due to accidents; or living 2 months in an average stone or brick building, due to potential for cancer caused by natural radioactivity.

I might add in this Rayburn Building, where we are presently sitting we have far higher radioactive emission than normal brick, because of the granite which we have.

And these numbers are not rigorous, hard facts, scientific givens, but they are an approach, they are an attempt to somehow put hazards in perspective. I think along with these everyday experiences, we can begin to put our energy and environment and our product safety and our workers' safety hazards, I think we are just doing ourselves a favor, when it comes to having to regulate and protect the public health and welfare.

I submit that the risk comparison technique is far more understandable and would be accepted by a greater number of people

than the absolute number game. Indeed, the major value of evaluating risk is the perspective gained and that perspective comes from comparison. I hope that our distinguished guests today can expand on this idea.

There is a real need to "bring risk analysis down from the mountain." I am convinced that we need to work hard to allow the nontechnical community to understand the value of risk analysis and the insights it can provide.

I would like to feel the Federal Government can help, indeed should help, in the field of risk analysis. There are many ongoing efforts in this field, both inside and outside of government. There are some very excellent people working in this field, it is the forefront and the interface of our society.

I believe more will be said about this later. There is a consensus of the need for further research in the field of risk analysis. The Federal Government has an appropriate role in this research effort because of the potential use of the techniques as an input to the Federal decisionmaking process.

I have authored legislation that would authorize an organized research and demonstration effort within our Federal agencies to develop risk comparison techniques and their use. That legislation is currently before this committee. I would like to take this opportunity to thank you, Mr. Chairman, for your past support of this legislation, and your current cosponsorship. It is my sincere hope that our bill, H.R. 3441, will result in significant progress in the field of risk analysis.

I am pleased that the Committee on Science and Technology is specifically having hearings on risk analysis and energy systems. I believe many of our energy systems have aspects that are not well understood by the Members of Congress. We need to consider all aspects of an energy system, from mining through waste disposal, as well as the benefits to be gained, if we are to take enlightened, responsible legislative action. Put them in context with one another and other risks we face in our society.

Risk analysis which considers the individual elements of an energy system will certainly help us with these actions. Putting those risks into perspective by comparison amongst energy sources will be very helpful to decisionmakers, and the public as well.

Mr. Chairman, again I commend you for having these hearings. Thank you for allowing me to say a few words. I believe risk analysis can help us bridge the technological/political gap.

It is again not a formula for legislative action, but it can help us to improve communications with our scientific community in the attempt to make better decisions and laws for all Americans. We will indeed have accomplished something. Thank you, Mr. Chairman.

[The prepared statement of Congressman Ritter follows:]

HONORABLE DON RITTER, TESTIMONY BEFORE HOUSE SCIENCE & TECHNOLOGY COMMITTEE HEARINGS ON SOCIETAL RISKS OF ENERGY SYSTEMS
JUNE 18, 1981

MR. CHAIRMAN, I CONGRATULATE YOU FOR HAVING THESE HEARINGS TODAY. I JOIN YOU IN WELCOMING OUR DISTINGUISHED GUESTS. SINCE JOINING THE U.S. CONGRESS NEARLY THREE YEARS AGO, I HAVE CONTINUALLY ENCOURAGED AND ACTIVELY PROMOTED THE CONCEPTS OF RISK ASSESSMENT AND RISK COMPARISON. I AM PLEASED TO SEE EVIDENCE OF THE INCREASING AWARENESS OF THESE CONCEPTS. RECENTLY, SECRETARY SCHWEIKER OF HEALTH AND HUMAN SERVICES VOICED HIS STRONG SUPPORT FOR AN EXTENSION OF THE MORATORIUM ALLOWING SACCHARIN ON THE MARKET. IN HIS STATEMENT, SECRETARY SCHWEIKER REFERRED TO THE RISKS AND BENEFITS OF PRODUCTS WE USE AND THAT THERE ARE FEW THINGS IN OUR SOCIETY TODAY THAT PRESENT A ZERO RISK.

WE ARE HERE TODAY TO CONSIDER THE SOCIETAL RISKS OF ENERGY SYSTEMS. ALL ENERGY SYSTEMS HAVE RISKS ASSOCIATED WITH THEM AND ENERGY IN OUR SOCIETY IS BEYOND JUST BEING A BENEFIT; IT IS A NEED. FOR REASONS WHICH WE ALL HAVE HEARD MANY TIMES, WE MUST GET ON WITH THE TASK OF CARRYING OUT AN ENERGY POLICY FOR THIS COUNTRY. AVAILABILITY, COSTS, NATIONAL SECURITY, ENVIRONMENTAL CONCERNS, HUMAN HEALTH AND SAFETY ARE MAJOR CONCERNS IN PUTTING TOGETHER SUCH A POLICY. MR. CHAIRMAN, YOU RECOGNIZE THE IMPORTANCE OF A SCIENTIFICALLY SOUND APPROACH TO THE ENERGY DECISIONS THAT THE CONGRESS MUST MAKE DURING THE 97TH CONGRESS.

LET'S ISOLATE FOR A MOMENT THE HUMAN HEALTH AND SAFETY ISSUE. HEALTH EFFECTS GENERALLY MEAN HEALTH HAZARDS. SO, FIRST WE NEED TO GET SOME IDEA OF JUST WHAT IS MEANT BY HAZARD. WHAT IS THE RISK TO THE PUBLIC? TO INDIVIDUALS? PUTTING HAZARDS INTO SOME

REASONABLE PERSPECTIVE MEANS WE AT LEAST NEED TO TRY AND ESTIMATE THE RISK OF EXPOSURE. THUS, WE NEED TO TRY AND ESTIMATE RISK IN A REASONABLE WAY. RISK ANALYSIS STUDIES OF ENERGY TECHNOLOGIES CONTRIBUTE TO POLITICAL DECISIONS AND MAKE THEM MORE INFORMED, EVEN EASIER. I HOPE THAT THESE HEARINGS TODAY WILL ACQUAINT MY COLLEAGUES WITH THE KIND OF BIPARTISAN APPROACH THAT RISK ASSESSMENT ATTEMPTS TO PROVIDE. MY VIEW AS A SCIENTIST AND AS A MEMBER OF CONGRESS IS THAT ENERGY POLICY DECISIONS ARE, IN THE FINAL ANALYSIS, POLITICAL IN NATURE, AND SHOULD BE SHAPED BY AN INFORMED PUBLIC AND THEN ELECTED REPRESENTATIVES; HOWEVER AFTER WITNESSING THE HIGHLY EMOTIONAL ENERGY DEBATES OF RECENT YEARS, OFTEN MIXING IDEOLOGY WITH SCIENCE, IT'S OBVIOUS THAT THE QUALITY OF THIS DEBATE WOULD BE INCREASED BY A LITTLE MORE OBJECTIVE SCIENTIFIC INPUT. LET'S FACE IT, WE ARE STARVED FOR BETTER SCIENTIFIC INPUT TO IMPROVE OUR DECISION PROCESS. I THINK YOU WILL HEAR TESTIMONY TODAY FROM OUR DISTINGUISHED GUESTS THAT WILL INCREASE YOUR CONFIDENCE IN THE POTENTIAL OF RISK ANALYSIS.

I HOPE THAT THESE HEARINGS HELP TO REMOVE SOME OF THE SCIENTIFIC MYSTIQUE THAT IS FREQUENTLY ASSOCIATED WITH RISK ANALYSIS. IN MY EFFORTS TO GAIN SUPPORT FOR THIS CONCEPT, I HAVE FOUND A RELUCTANCE TO ACCEPT IT BECAUSE OF A FEELING THAT IT IS TOO COMPLEX. RISK ANALYSIS THAT RESULTS IN SOME NUMBER IS MEANINGLESS UNLESS YOU CAN RELATE IT TO SOMETHING THAT IS KNOWN TO PEOPLE. I BELIEVE THAT AN EFFECTIVE CONSIDERATION OF RISK SHOULD RESULT IN A COMPARISON OF RISKS INCLUDING THOSE RISKS TAKEN IN COMMON, EVERYDAY EXPERIENCE. LET ME GIVE YOU AN EXAMPLE: WHEN EVALUATING THE HAZARD THAT EATING EGGS PRESENTS, ONE FINDS THAT EATING ONE-HALF DOZEN EGGS, ON THE AVERAGE, INVOLVES ONE CHANCE IN A MILLION OF ONE DEATH PER YEAR DUE

TO CHOLESTEROL INTAKE. IT CAN ALSO BE SAID THAT THE CONSUMPTION OF SIX EGGS IS EQUALLY AS HAZARDOUS AS SMOKING 1.4 CIGARETTES, LIVING TWO DAYS IN NEW YORK OR BOSTON (AIR POLLUTION); TRAVELING 10 MILES BY BICYCLE (DUE TO ACCIDENTS); OR LIVING TWO MONTHS IN AN AVERAGE STONE OR BRICK BUILDING (DUE TO CANCER CAUSED BY NATURAL RADIOACTIVITY).

I SUBMIT THAT THE COMPARISON TECHNIQUE IS FAR MORE UNDERSTANDABLE AND WOULD BE ACCEPTED BY A GREATER NUMBER OF PEOPLE THAN THE ABSOLUTE NUMBER ANALYSIS. INDEED, THE MAJOR VALUE OF EVALUATING RISK IS THE PERSPECTIVE GAINED AND PERSPECTIVE COMES FROM COMPARISON. I HOPE THAT OUR DISTINGUISHED GUESTS TODAY CAN EXPAND ON THIS IDEA. THERE IS A REAL NEED TO "BRING RISK ANALYSIS DOWN FROM THE MOUNTAIN." I AM CONVINCED THAT WE MUST WORK HARD TO ALLOW THE NONTECHNICAL COMMUNITY TO UNDERSTAND THE VALUE OF RISK ANALYSIS AND THE INSIGHTS IT CAN PROVIDE.

I WOULD LIKE TO OUTLINE HOW I FEEL THE FEDERAL GOVERNMENT CAN HELP, INDEED SHOULD HELP, IN THE FIELD OF RISK ANALYSIS. THERE ARE MANY ONGOING EFFORTS IN THIS FIELD, BOTH INSIDE AND OUTSIDE OF GOVERNMENT. I BELIEVE MORE WILL BE SAID ABOUT THIS LATER. THERE IS A CONSENSUS OF THE NEED FOR FURTHER RESEARCH IN THE FIELD OF RISK ANALYSIS. THE FEDERAL GOVERNMENT HAS AN APPROPRIATE ROLE IN THIS RESEARCH EFFORT BECAUSE OF THE POTENTIAL USE OF RISK ANALYSIS AS AN INPUT TO THE FEDERAL DECISION MAKING PROCESS. I HAVE LEGISLATION THAT WOULD AUTHORIZE AN ORGANIZED RESEARCH AND DEMONSTRATION EFFORT WITHIN OUR FEDERAL AGENCIES TO DEVELOP RISK COMPARISON TECHNIQUES AND THEIR USE. I WOULD LIKE TO TAKE THIS OPPORTUNITY TO THANK YOU, MR. CHAIRMAN, FOR YOUR PAST SUPPORT OF THIS LEGISLATION

AND YOUR CURRENT CO-SPONSORSHIP. IT IS MY SINCERE HOPE THAT OUR BILL, H.R. 3441, WILL RESULT IN SIGNIFICANT PROGRESS IN THE FIELD OF RISK ANALYSIS.

I AM PLEASED THAT THE COMMITTEE ON SCIENCE AND TECHNOLOGY IS SPECIFICALLY HAVING HEARINGS ON RISK ANALYSIS AND ENERGY SYSTEMS. I BELIEVE MANY OF OUR ENERGY SYSTEMS HAVE ASPECTS THAT ARE NOT WELL UNDERSTOOD BY THE MEMBERS OF CONGRESS. WE NEED TO CONSIDER ALL ASPECTS OF AN ENERGY SYSTEM, FROM MINING THROUGH WASTE DISPOSAL AS WELL AS THE BENEFITS TO BE GAINED, IF WE ARE TO TAKE ENLIGHTENED, RESPONSIBLE LEGISLATIVE ACTION. RISK ANALYSIS WHICH CONSIDERS THE INDIVIDUAL ELEMENTS OF AN ENERGY SYSTEM WILL CERTAINLY HELP US WITH THESE ACTIONS. PUTTING THOSE RISKS INTO PERSPECTIVE BY COMPARISON AMONGST ENERGY SOURCES WILL BE HELPFUL TO DECISION MAKERS, AND THE PUBLIC AS WELL. I AM ANXIOUS TO HEAR OUR EXPERTS TODAY EXPAND ON THIS ISSUE.

MR. CHAIRMAN, AGAIN I COMMEND YOU FOR HAVING THESE HEARINGS. THANK YOU FOR ALLOWING ME TO SAY A FEW WORDS. RISK ANALYSIS CAN HELP US BRIDGE THE TECHNOLOGICAL/POLITICAL GAP. IT IS NOT A FORMULA FOR LEGISLATIVE ACTION BUT IT CAN HELP US TO IMPROVE COMMUNICATIONS WITH OUR SCIENTIFIC COMMUNITY IN THE ATTEMPT TO MAKE BETTER DECISIONS AND LAWS FOR ALL AMERICANS.

Mr. FUQUA. Thank you for a very fine statement. On page 3 you mentioned the fact that the Federal Government has an appropriate role in research on risk. Do you have any suggestions or ideas where this should be located? Should it be in the various departments, should there be a new agency, or should it be housed in one of the current Federal agencies that we have now?

Mr. RITTER. I think far be it from me to suggest any new Federal agency. I believe that the agencies that we have today, that are responsible for regulating health and safety and environmental matters, are the proper agencies in which to begin to use these techniques and to seek input from these techniques.

I think a coordinative role can occur perhaps through the Office of Science and Technology Policy, and some of the coordinative groups that exist between the agencies. But the real key here is the different—are the different agencies that are faced with the responsibility and they are the ones who will benefit most from the use of this technique.

Mr. FUQUA. Thank you. Mr. Shamansky?

Mr. SHAMANSKY. Thank you, Mr. Chairman. I am concerned, Congressman Ritter, with your statement to the effect that we are not talking about numbers, we are talking about comparisons. I was listening to the comparisons of the very illustrative situations you made, but it seems to me there has to be some kind of numerical reduction initially. You don't mean to imply that there isn't?

Mr. RITTER. I am sorry. My thought was that the output, the product, is not a number. It is the kind of perspective you gain from the numbers. But you do need to analyze to bring you the original numbers so that you can begin to compare one particular hazard against another or to develop a perspective for that hazard.

Mr. SHAMANSKY. I wanted to clear that up. With respect to methodology, there has to be basic numerical but standard criteria. You would establish that and then you would go into the comparison aspect?

Mr. RITTER. Yes.

Mr. SHAMANSKY. Thank you very much, Mr. Chairman.

The CHAIRMAN. Mr. Winn?

Mr. WINN. Thank you, Mr. Chairman.

I want to commend the gentleman from Pennsylvania for the outstanding work that he has done. He stayed with this ever since he was a member of the committee. He has talked to me about it several times and urged the chairman and myself to take some action on this issue, and I want to commend him.

I would like to ask what kind of information material do you recommend for those of our constituents who seem confused about the relative risks of the different energy systems?

Mr. RITTER. It is a very good question and the bottom line in having an educated public in this area is somehow getting the messages out. You have right now the major medium of communication as the public media. In fact, at one point I gave a seminar to a group of editors and journalists on the subject, and I kind of cutely entitled it "Do you Lose the Front Page if You Put Risks in Perspective." And everybody kind of agreed that you did, which was not good considering the personal economics of all of these people. But they agreed that they had a higher duty to their

profession and their code and not long after a major article appeared in my own local paper from a journalist from my district that didn't exactly take into account any sort of risk comparison.

The mechanisms are poor at the present time. Perhaps through our universities, perhaps better contacts between industry and universities, industry and the media, I think people who generate products or processes or energy sources have got to go on to perhaps go out from their offices and really talk to those people in the public media, whether it is in the TV media or it's in the newsprint, and they have got to be firm, they have got to be direct, because those—many of those messages are just not getting through. I think legislation in this area could well consider the idea of how do you communicate hazards in perspective to the public. We are not doing a good job of it.

Mr. WINN. You mentioned the media where you have the possibility of public service. But as we all know, you very seldom see any public service announcements certainly of this type in the news.

Mr. RITTER. It's not about to make the front page.

Mr. WINN. It would be presented at 5:30 in the morning or 11:30 or 12 o'clock at night. It's a problem and I wondered if you had any ideas.

Mr. RITTER. One of the real problems we face in the area of making decisions in this society, in perspective, putting hazards in perspective, is the communications problem. It's the fact that the public is whipsawed by whomever is making that front page and it makes big news.

Mr. WINN. Thank you, gentlemen, thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Winn. Mrs. Bouquard.

Mrs. BOUQUARD. Thank you very much.

I would also like to welcome you, Don, back to the committee today. It's good to see you.

Mr. RITTER. It's good to see you.

Mrs. BOUQUARD. I congratulate you on this legislation. I think it is the mechanism to relate better to the constituents as to the relative benefits and hazards and to determine if is it worth the risk. I think it will help us to make more accurate policy decisions.

I would like to touch on another point. Obviously there are risks involved in not having sufficient energy production, and risk analysis doesn't quantify this type of risk as well?

Mr. RITTER. Well, there is no doubt, that is a very good point, Marilyn. If you think about what the greatest risk in our energy economy today is, it's cutoff of Middle Eastern oil, it's a highly unstable part of the world that could blow up at any moment.

That even gets beyond some things we are talking about here today. But when you talk about 3½—or 3 million barrels, I guess we have of oil a day coming from some very unstable—at least a couple of those million barrels come from some very unstable regions, that is one heck of a risk.

Mrs. BOUQUARD. Thank you very much. Thank you, Mr. Chairman.

Mr. FUQUA. Mr. McGrath?

Mr. MCGRATH. Thank you, Mr. Chairman. Don, I want to thank you for coming to testify. I congratulate you on being here because

I like to hear somebody who both has political as well as some scientific perspective on a particular problem.

I have a particular problem in my district which you might be able to comment on. Perhaps all of the other panel members today, our distinguished guests would also like to comment. There is seemingly a catch 22 in an area of energy production and garbage disposal.

My district has two landfills right now that are filled to the top. A couple of years ago we erected with private funds a $100 million garbage disposal site which was supposed to reduce the garbage to ash for disposal. In addition, it's supposed to reclaim recyclables and also produce electricity.

While it was working, it was doing all of those things. The fact simply is that in some of the tests that were conducted subsequent to the beginning of the operation, they found that there were some emissions into the air that could prove to be carcinogenic. How minute those emissions were is another story.

The fact is because of those emissions the plant, which is a $100 million facility, has been shut down. There is no standard established by the EPA, they said they cannot establish a standard without opening the plant again for some tests. That is the position we find ourselves in now.

In the last study that was done, it seems to be a couple of parts per trillion of dioxin that were being admitted into the air. The plant has been closed. We are in a catch 22 where the plant can't open.

I don't want my constituents used as guinea pigs for experimentation, but at the same time, we are double parked, frankly, on our ability to dispose of the garbage which is going to create as big or a bigger environmental problem than perhaps the opening of the plant would.

So from your perspective, both as a political figure and also as a scientist, perhaps you can address that particular risk situation that I find myself in today.

Mr. RITTER. I will try, but—incidentally, a couple parts of 1 trillion could not have been detected 10 years ago. And in 10 years, we will perhaps even double the detectable limits beyond a couple parts of 1 trillion or increase it maybe by several orders of magnitude. We will have those kind of sensitive instruments.

So what we are facing is chemistry has done a super job and before, what we didn't know really didn't hurt us that much or at least we didn't think it was hurting us, but we didn't do anything about it.

Our ability to deal with advanced chemistry has not really kept up with that chemistry. In your situation other than waving a magic wand and hoping for the best, you have a local laboratory there or in your area which has some very high-powered chemistry facilities, and it may be that some tests could be generated to view the effects of this particular hazard.

I think right away, if you could get some good idea as to what the potential comparative risks are of not disposing of this waste to what the environmental conditions would be by not incinerating, I think that might allow opening of the plant in an environment which is politically acceptable.

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Even though it is two parts per trillion, we are not really sure we are doing tests, but if we know if the garbage builds up, this is what is going to happen and we are pretty sure of that. We don't want to risk that. That might be a way of going. You will have to make that decision.

Mr. McGRATH. Are there any facilities that you are aware of today that may be comparable in nature so that perhaps burning of similar type garbage could produce an effect that would be the same. Then the process could be studied without having to open up this plant, which would cause a political turmoil?

Mr. RITTER. I would assume whoever is running this plant is in contact with people who had similar experiences.

Mr. McGRATH. Thank you.

Mr. FUQUA. Mr. Weber?

Mr. WEBER. I found your testimony very interesting. I am a new committee member on the committee, and I need to be brought up-to-speed on where we stand.

I understand you are advocating a particular mode of risk assessment which is a comparative model.

Mr. RITTER. Sort of a second stage, you have to do the assessments first, then you compare them.

Mr. WEBER. Do other people advocate other means of measuring risks, and could you tell me what other options might be put forward?

Mr. RITTER. Risk assessment or risk analysis is kind of a first step. And you need, as Mr. Shamansky was pointing out, you do need some kind of numbers based to make these comparisons.

Mr. WEBER. Is there an agreement on that phase? Scientists and other people, do they agree on how we measure?

Mr. RITTER. The methodologies are not fully agreed upon. There are some differences, there are several different ways of doing it. One would suspect that if one was comparing risks, that one should use a similar methodology and try to get out from under the guise that the metholdogy may not be perfect, so apply a similar methodology to similar risks.

Risk comparison simply is second stage of the assessment process, but it is very necessary, because if you just talk about a particular risk to a particular population, the individuals in that population will simply think it is them and will not want to be subjected to a risk.

They say, I could go hang gliding without wanting that power plant to do that to me. So what you have to do is put into context with other thinking that they are doing on a daily basis or other public goods that they accept, they have certain risks perhaps, too.

Mr. WEBER. This is for my own benefit. In what areas do we find the broadest disagreement on the means of measuring risk in the first place? What are the really hot areas of the controversy, where the community does not agree on how we go about assessing risk?

Mr. RITTER. There is as much disagreement with that as there is disagreement with using a technical tool in a social and political process. We have gotten many responses initially when we had our first hearings that, you know, this is a social problem. It is a political problem.

What are you doing with this kind of technical decisionmaking tool, and my answer was, I just want to have it around to contribute to that social and political process, because I think given our experience of emotions caught up in regulating—often regulating trivia, not always, we could use a little help from our friends in this regard.

Mr. WEBER. I presume people who don't want to look at it from a scientific viewpoint, but look at it socially or politically, are advocating a zero risk factor?

Mr. RITTER. That's right. In many regards, there is an ideological component to some of these.

Mr. WEBER. Thank you very much. I have no more questions.

The CHAIRMAN. Mrs. Schneider?

Mrs. SCHNEIDER. Can you tell me if you have done any economic analysis on the cost of such a program?

Mr. RITTER. We have not. We have asked to put the program within the original program, the research development demonstration aspect of it within the National Science Foundation's existing program plans.

We feel that the kinds of work that could be done is not necessarily that expensive. It is—some researchers out in some universities, basically, or some think tanks.

And also there is a component to the program that would come out in the Federal agencies. Federal agencies such as EPA and FEA and CPSC, Consumer Product Safety Commission, and some of these other agencies are already getting involved. They are sort of—they have begun to work on this. It is a kind of idea whose time is arriving and we would like to coordinate a little bit, speed them up a bit, and see that they make progress for their regulatory decisions.

Mrs. SCHNEIDER. I think one of the most amazing things that I have learned while serving on my other Subcommittee on Science and Technology is the lack of integration of scientific research on a broad spectrum of subjects, and I think that——

Mr. RITTER. Between the Federal agencies?

Mrs. SCHNEIDER. Yes.

Mr. RITTER. That is a legend.

Mrs. SCHNEIDER. I don't think we should perpetuate that legend. I think if your legislation were to address an appropriate network for integration of research, that I think would be taking a step in the right direction.

Mr. RITTER. I think you are exactly right, Claudine, and to the extent that we are kind of still groping with the new administration's interagency review group, types of programs and how the Office of Science and Technology will actually function, we think—we have been waiting for that coordinative—we have been waiting around to better define the coordinative role and until we see how the administration sets up its coordinative role.

Mrs. SCHNEIDER. Another question I have is based on what happens after we do the research. What do we do with it? This relates a little bit, I think, to Congressman Weber's question.

It is of interest to me to know whether or not this would be a mechanism to determine what direction our energy policy would take and if there would be any built-in provisions for public partici-

pation or open hearings within your legislation? Once you have the risk analysis of various energy technologies, would there then be public hearings to comment on those risks?

Mr. RITTER. I think it is an excellent idea. And the bottom line, when you get right to it, the bottom line is to help the public to gain the best understanding—not just people in this place or people in the Federal agencies, but the public in the final analysis, Congressmen will vote to what their constituents are telling them back home. So public exposure to the process could be one of the ways of communicating some of these ideas out into the voting public.

Mrs. SCHNEIDER. Thank you very much.

Mr. FUQUA. Thank you. Mr. Dunn, you indicated you have no questions.

Mr. Walgren?

Mr. WALGREN. I wanted to say how much I personally think of the efforts that Mr. Ritter had made in raising the question of risk analysis and the work that has gone into the legislation that he has proposed.

Last year, the subcommittee which I now chair in this Congress, the Subcommittee on Science Research and Technology, held 2 days of hearings on that legislation. And although it didn't come to fruition last year, I want to say that the subcommittee remains more than interested in that legislation and I want to be sure that the work that was put into it is not lost. So, our subcommittee will be looking at that bill, with an eye to marking up something in this area. And it is really because of Mr. Ritter's persistence in keeping our attention on that subject. It is a most important subject.

I can't quite get straight in my mind the difference between the risks which may or may not happen and the concept of risk to an individual which, when seen from an overall population viewpoint, is a certainty to a number of individuals in that population. Even though I may not be the one to draw the short straw, if there is a short straw in there, somebody will draw it. And so those are really major questions for this type of situation.

Mr. RITTER. I think certainly in the area of workplace safety, the population you have to deal with is the population inside the plant. It is not the population 10 miles away.

Mr. WALGREN. My point is, though, and maybe now is not the time to engage in the point, but it seems to me that there are two kinds of risks. One is something that may or may not happen. There is another concept of risk that has to do with the following kind of situation. If you have 100 people each driving 100 miles, we know from past experience that one of those people is going to have that accident and could be killed. The insurance companies can tell you, it cost you 10 lives to build a bridge, it costs you 10 lives to mine so much coal.

There is a point where some of these things reach a certainty from a population viewpoint, although a mere probability from an individual's viewpoint. Now maybe I am wrong about that, but it is something that I think deserves some thought.

In any event, my point is that your bill, which you introduced in the last Congress, is one which our subcommittee intends to mark

up, and we hope to be able to bring it to the broader consideration of the full committee.

Mr. RITTER. Let me add that that question you bring up may be the public risk, the risk of the public good versus the private risk; and that is another thing that has to be considered.

What this committee does in marking up and providing legislation, I think, is very, very useful to other committees who are discussing these subjects right now.

Agriculture is looking at this very question in terms of the use of its own chemicals, for fertilizers and pesticides. Energy and Commerce, which I serve on now, has a tremendous use for these kinds of—at least beginnings of some real reasonably organized approaches to Federal regulation, using risk comparison or analysis techniques.

So what you did here, I think, has some marked effects in those areas of the Congress which are concerned with regulatory process. I want to thank you again.

There was a decision the Supreme Court came down with the other day. It was talk about the current law and the ability to make judgments on a cost-benefits basis. And either you change the current law or you are going to have continuing problems with trying to evaluate on a cost-benefit basis, evaluate safety questions, health questions, environmental questions.

I think what risk analysis does and risk comparison does is try to get away from putting dollar figures on somebody's hands or somebody's life; even though it may be a very small probability, it is always going to be somebody and the courts, given current law, are not going to look favorably upon that pricing of health and safety.

So it is important, in particular, in light of the current recent Supreme Court decision.

Mr. FUQUA. Thank you very much, Mr. Walgren. Thank you very much, Don. We invite you to stay here in the hearing if you have time. If you want to come up and sit in your former seat, that would be allowed.

At this time, we would like to introduce our panel, Dr. Lester Lave, with the Brookings Institution. Dr. Lave, we are happy to have you here. And joining him will be Dr. William Ramsay, Center for Energy Policy Research at Resources for the Future, located here in Washington, D.C. I would like to call on Mrs. Bouquard to introduce Dr. Richmond from the Oak Ridge National Laboratory.

Mrs. BOUQUARD. Thank you very much, Mr. Chairman. As you well know, in the 7 years that I served on this committee I encountered many risks and benefits.

One of the benefits in serving on this committee is gaining insight from some of the fine people from our Oak Ridge National Laboratory and today is certainly no exception.

It is my pleasure to welcome Dr. Chester Richmond, who is associate laboratory director for biomedical and environmental sciences in our laboratory.

Mr. FUQUA. Thank you. We are happy to have you with us. Dr. Richmond, Dr. Lave, we would be pleased if you would start off.

[The biographical sketches of Dr. Lave, Dr. Ramsay, and Dr. Richmond follow:]

LESTER B. LAVE

Lester B. Lave was born in Philadelphia, Pennsylvania in 1939. He received his B.A. from Reed College (1960) and Ph.D. from Harvard University (1963). He has taught at Harvard University, Northwestern University, and the University of Pittsburgh, and was chair of the Department of Economics of Carnegie-Mellon University from 1971-1978. Dr. Lave is presently a Senior Fellow in the Economic Studies Program at the Brookings Institution and Professor of Economics at Carnegie-Mellon University.

Dr. Lave has received grants from both government agencies and foundations to support policy research on health care, the environment, automobile safety, bargaining behavior, the value of information dissemination, and energy, among other social issues. He has been a consultant to almost every Cabinet-level department as well as many private firms, and is a member of various professional associations. Dr. Lave has served on committees of the National Academy of Sciences and the American Association for the Advancement of Science. He is author of more than 150 publications, including two new books: The Strategy of Social Regulation and The Scientific Basis of Health and Safety Regulation. In addition, Dr. Lave is an associate editor of several journals.

BIOGRAPHICAL SKETCH

William Ramsay, after earlier research in high-energy nuclear physics and astrophysics, has studied the systems analysis of village economies, urban land use, and waste-management systems. From 1972 to 1975, at the Atomic Energy Commission, he worked on environmental aspects of energy production, and later, as technical adviser to one of the commissioners of the Nuclear Regulatory Commission, he dealt with nuclear proliferation, safety, and risk analysis. He joined Resources for the Future in 1976 and now is a senior fellow there. His research at RFF has focused on health and environmental costs of conventional and renewable energy sources and, more recently, on energy economic problems in developing areas.

BIOGRAPHICAL INFORMATION

CHESTER R. RICHMOND

Dr. Chester R. Richmond is the Associate Laboratory Director for Biomedical and Environmental Sciences at the Oak Ridge National Laboratory (ORNL). Dr. Richmond is responsible for all life sciences research at ORNL. He also is responsible for all studies sponsored at ORNL by several agencies, including the National Science Foundation, the Enviromental Protection Agency, and the Departments of Agriculture, Interior, and Health and Human Services. Four research divisions -- Biology, Environmental Sciences, Health and Safety Research, and Information Research and Development, as well as the Life Sciences Synthetic Fuels Program -- report to Dr. Richmond. The divisions contain a total of approximately 800 people. The multidisciplinary research programs in life sciences involve (a) biological studies of carcinogenic, mutagenic, and toxicological effects of pollutants associated with energy and other technologies, (b) ecological studies of the effects of energy technologies on particular ecosystems and assessments of present and future effects of energy-related pollutants, and (c) studies of the physics, chemistry, and quantitative measurement of pollutants.

In May 1981 Dr. Richmond also became the Director of Health, Safety, and Environmental Affairs for Union Carbide Corporation's Nuclear Division.

Before coming to ORNL in 1974, Dr. Richmond was the Alternate Health Division Leader at the Los Alamos Scientific Laboratory (LASL). His research at LASL led to his being awarded an E. O. Lawrence Award in 1974 for "research in radiation biology of internally deposited radionuclides and outstanding contributions to the resolution of radiation protection problems." Dr. Richmond received the Radiation Research Society Award and delivered the G. Failla lecture in 1976. He is the author of more than 100 publications on radiobiology and health and environmental effects of energy production. He received his B.A. in Biology from New Jersey State College and his M.S. and Ph.D. in Biology-Physiology from the University of New Mexico in Albuquerque.

Dr. Richmond is a member of the International Commission on Radiological Protection Committee 2 on Secondary Limits and the International Radiation Protection Association. He has served on panels and coauthored reports for the International Atomic Energy Agency, the International Commission on Radiological Protection and the Organization for Economic Cooperation and Development. He is also a member of the U.S. National Council on Radiation Protection and Measurements. He has served on a National Research Council Planning Conference on Synthetic Fuels and is on the Steering Group for the Society for Risk Analysis. He is a Fellow of the American Association for the Advancement of Science and a member of Sigma Xi and numerous other professional societies. He is the scientific advisor to the International Symposium on Health Impacts of Different Sources of Energy sponsored by the World Health Organization, the United Nations Environment Program, and the International Atomic Energy Agency to be held in June 1981.

June 1981

STATEMENTS OF DR. LESTER LAVE, THE BROOKINGS INSTITUTION, WASHINGTON, D.C.; DR. WILLIAM RAMSAY, CENTER FOR ENERGY POLICY RESEARCH, RESOURCES FOR THE FUTURE, WASHINGTON, D.C.; AND DR. CHESTER R. RICHMOND, ASSOCIATE LABORATORY DIRECTOR FOR BIOMEDICAL AND ENVIRONMENTAL SCIENCES, OAK RIDGE NATIONAL LABORATORY

Dr. LAVE. As I was listening to the questions I thought of throwing away my statements and addressing those.

Mr. FUQUA. One of the technologies that we do not have in the committee is efficient microphones. You have to pull it very close to you.

Dr. LAVE. Thank you.

Mr. FUQUA. It is one of the risks we have here, not being able to hear you.

Dr. LAVE. Let me just briefly summarize what I have in my statement and perhaps address one or two of the questions that stuck in my mind.

The first point is that social goals are not simple. For example, we want cheap, reliable, and safe electricity. When we regulated nuclear power in the past we seem to have been concerned only with safety, chasing a mirage of absolute safety in making nuclear power extremely expensive and in many cases eliminating its competitive edge.

We should have been trying to balance these three objectives of safety, price, and reliability. In a recent paper in Science, I demonstrated that congressional concern with the automobile, in 1966 in regulating safety, in 1970 regulating emissions, and 1975 in regulating fuel economy, was all seemingly very sensible.

Emissions controls lowered fuel economy; fuel economy tended to lower safety. We can't really have all three goals at the same time; there is a necessity for doing some balancing.

The subject of the hearings today is risk and safety. It is important to keep in mind that the safety level of energy or other activities in our society is only one of the aspects of that that is important to us. As we try to address safety, we should keep in mind these other aspects.

I was asked to spend just a moment reminding you of what risk analysis is and so with your patience I will do that very quickly. To do a risk analysis, it is important to begin by finding the areas of possible risk. It is kind of important to go on and estimate the dose-response relationship, whether for accidents or chronic disease. The next step is measuring the number of people exposed and at what levels. Finally, one must characterize risk level.

There were a number of questions asked of Congressman Ritter which are relevant. There are some people who think that the right measure of risk is the maximum possible number of people who could be injured if something untoward happens. In the case of nuclear power that is called a maximum credible accident. I might point out if we all ran our lives by the maximum credible accident, none of us would have gotten out of bed this morning, because the maximum credible accident would have had us dying before we even got downstairs. I don't think that is a good way of running our lives.

There are other characterizations of risk that are relevant. One of the difficulties is trying to figure out what characterizations of risk are most relevant for the public and for other decisionmakers in trying to look at various energy systems.

Again as emphasized in the questions of Congressman Ritter, this area of quantitative risk assessment is not one that is simple and straightforward. It is rather difficult to apply. For example, there are approximately 200 people who are killed each year when a rail train carrying coal collides with a vehicle or with people on the tracks.

One of the ways of mitigating the hazard would be to build road crossings and the fences along the right-of-way. Both of those would be extremely expensive and probably would not be effective. If one steps back, there is probably an alternative technology that could reduce those risks even more; namely, coal slurry pipelines, but that is a different set of concerns.

When one is trying to deal with risks to health of disease, then there are a myriad number of problems. For example, what are the effects of minute quantities of carcinogens, some parts per trillion. The effects are on the edge of biomedical science, or perhaps beyond their capabilities of prediction.

What is even more difficult is the notion of interactions between those risks and exposures to other kinds of substances. For example, if one is exposed to a number of carcinogens, there is some suggestion that the risks may be greater than the sum of risks to each individual carcinogen; that is, that there is a synergistic or positive interaction effect.

In addition, there are differences among individuals in terms of their genetic composition and their habits, leading to differences in susceptibility. It is extremely difficult to characterize risk.

Congressman Ritter quoted the risk of consuming half a dozen eggs. If one happens to be an individual with very low blood cholesterol, then it is probable that the risk of consuming half a dozen eggs is zero unless one tries to swallow one whole and chokes on it. Yet the estimate for the population as a whole is reasonable since many people do have problems with cholesterol.

To bring it to the subject at hand, I have attempted to display some recent calculations and the risk levels of various energy systems. This is an area where the very first attempts to get at these risks date back less than a decade. Those first studies showed that the risks associated with generating electricity from coal were much greater—that is, on the order of 100 to 10,000 times greater—than the risk of generating the same amount of electricity from a nuclear reactor. Those analyses have been refined and there have been a number of alternative ways of generating energy which have come about.

In the table in my testimony, I have reprinted some work done at Brookhaven National Laboratory showing the latest risks of coal, nuclear, and a series of other technologies. What is interesting is that many people believe that solar energy is the preferred route for the future; they view solar energy as the most benign of technologies. This analysis shows that is far from true. Your intuition can lead you astray. Solar energy has associated with it, depending on precisely which technology you are considering, risks

which can be significantly higher than the risks of either coal or nuclear.

That is not proof we ought to give up all solar technologies; rather, it is evidence that if you were trying to go to solar technologies because you were afraid of the risks of coal or nuclear, you were being misled.

One final comparison. The other bit of popular wisdom is that burning wood is a wonderful technology. Again, the people at Brookhaven have done some preliminary analyses on the risks associated with burning wood to heat your home. They have found that the risks of collecting wood and burning it, including the resulting air pollution, are many times higher than the risks of alternative technologies, particularly home heating using either electricity or natural gas.

These comparisons show that intuition about the safety of energy technologies is unreliable.

Let me take a moment to address a couple of the issues that were raised in the questions to Congressman Ritter:

The first is that risk comparisons are dominated by uncertainties. Risk analyses reveal vast numbers of uncertainties; it is important not to ask more of a risk analysis than it can give.

The risk analysis isn't going to point out a single technology as being unequivocally safer than all others. Rather, it may be able to show that there are some technologies that are vastly riskier than others—that should not be used. Another a set of technologies will have comparable risks; choosing among them will require criteria other than risk.

The last point is that this is an imperfect tool. The relevant question is why anybody should spend their time on it. To that there is a simple answer: Congress and the regulatory agencies are making decisions that involve expenditures of billions of dollars each year. For expenditures of that magnitude, it is unsatisfactory to rely on guesses.

We need to have more facts than that. It is unfortunate that the facts are not any better than we can get at with risk analysis right now, but I think if we try and push the analysis and data, that we will get much better facts in the future.

Thank you.

[The prepared statement of Dr. Lave follows:]

Testimony before Committee on Science and Technology

The Risks of Alternative Energy Sources

Lester B. Lave

Brookings Institution
June 18, 1981

Introduction

In this testimony I will sketch the methods of estimating the risks, particularly to health, of energy systems. Some of the difficulties in analyzing these risks will be discussed along with current methods of solving them. Finally, I will present the results of analyses of the risks of a number of current energy sources including nuclear reactors, coal fired plants, various solar energy technologies, and the use of wood for home heating.

The Complexity of Setting Goals

Social goals are rarely simple and actions to achieve them never have a single consequence. We desire electricity that is cheap, safe, and reliable. No one is satisfied to have electricity that is extremely expensive, but is safe and reliable, or indeed, to achieve any two of the three attributes while sacrificing the third. As I illustrated in a recent paper on federal regulation of the automobile, society is not well served by ignoring any of the significant aspects of a problem (Lave, 1981a). In the case of the auto, over ten years Congress successively regulated safety, emissions, and fuel economy, and may yet get around to regulating the other important aspects such as price and styling.

As the auto paper shows, a second lesson is that society is not well served by considering one goal at a time; regulation of fuel economy was necessitated partly by the regulation of safety and emissions. The relevant goals have to be considered simultaneously so as to reconcile the pulls and and tugs of conflicting goals. In setting national energy policy, we have been guilty of focusing on one attribute at a time and ignoring the effects of our decisions on other attributes. For example, the only attribute of importance in regulating nuclear power has been safety. The consequent ignoring of cost and reliability has reduced, and in many cases eliminated, the competitiveness of nuclear power. Project independence considered only reliability and produced a plan that had vast increases in cost and important compromises in safety.

I have simplified by discussing the attributes of cost, safety, and reliability. For energy, other attributes include the future supply of fuel and international aspects of our decisions. All five of these attributes or dimensions of the problem must be considered together in arriving at a national energy policy. Safety does not dominate the decision, but neither can it be ignored. What follows is an attempt to explore and quantify safety aspects of energy decisions. These aspects are but one of five that must be considered in arriving at sensible energy policy.

A Primer on Risk Analysis

To determine the risks of accidents associated with a project, one must begin by deliniating those parts of the project where there is an accident risk (Lave, 1981b). The second step is to determine the type of injury and probability of injury associated with each risky part. The third step is to find a number of people exposed to each risk. The final step is to characterize the hazard (magnitude of possible harm), who is at risk, and the expected number of injuries of each type.

To determine the risks of occupational disease or disease in the general population, the steps are similar. The first step is determining the substances to which people are exposed. The second step is to determine the dose-response relationship for each substance. The third step is to determine the population at risk and the dose received by each person. The final step is to characterize the type and amount of disease expected for each group, the amount of disability and premature death.

It is relatively easy and straightforward to describe the procedures for characterizing accidents and disease; however, applying these procedures is rarely easy or straightforward. For example, accidents are rarely due to a single cause. Instead, a number of factors contribute, generally including some human mistake or lack of attention. What really caused the accident and what is the cheapest (and most reliable) method of preventing it? For example, a large number of people are killed each year in accidents involving freight trains; generally there is a collision between the train and a vehicle

at a crossing. Since coal represents a large fraction of railroad tonnage, a large number of accidents must be attributed to carrying coal. What is the cheapest and most reliable way of eliminating these accidents? A very expensive way is building grade crossings and putting up fence along the right of way. The latter is unlikely to be effective in preventing people from getting close to the tracks. The best alternative might be to substitute coal slurry pipelines for freight trains.

The difficulties associated with occupational disease are much greater. There are myriad toxic substances in minute quantities in the workplace and in the surrounding environment. Occassionally the concentration and resulting dose are great enough to produce an acute effect. More generally, minute doses contribute to some unknown increase in chronic disease. Often latency periods of several decades are involved, the actual incidence of the resulting disease is known, and rarely can one be certain of the cause of a particular disease.

Epidemiological studies provide some evidence about the health effects of various occupations and exposures. More generally, there is at best information from animal bioassays, or no information at all.

Estimating the population at risk and the dose they receive is conceptually straightforward, but extremely difficult in practice.

Even assuming the analysis can be performed, the result is a set of disparate health effects, accidents involving consequences that range from trivial to fatal and a set of disease effects that range from slight, acute effects to chronic disease resulting in death. To make sense of this array of effects, one must aggregate them somehow.

But how many slight injuries are equivalent to a serious injury? How many serious injuries to a fatality? Is a fatal accident better or worse than a fatal cancer?

Some effects, such as accidents and acute disease occur immediately; some occur only after decades. What is the cost to society of a fatality now versus a fatality in thirty years?

Some people believe it is important to distinguish between accidents or disease to workers and to the general public. Workers generally know the nature of the risks and are paid to assume the risks. The general public is often not aware of the risks and is loathe to have the risks imposed on them.

The point to be emphasized is that the risk assessment is a careful, systematic attempt to estimate the health effects of an energy technology and to aggregate the risks so that the decision makers can make sense of them. For the situations at issue, it is extremely difficult to estimate the effects with confidence. For example, the public health effects of air pollution from burning coal are subject to intense controversy. While one cannot accept the estimates as gospel, one should not dismiss them as guesses. They should be an important input to energy policy, but one must be careful to recognize the amount of uncertainty associated with each estimate.

A Comparison of Current Energy Technologies

Systematic attempts to infer the risks of energy technologies date back less than one decade (Lave and Freeburg, 1973; Sagan, 1973, 1974). The early studies focused on electricity generation

technologies and compared coal with nuclear, with some consideration given to oil and natural gas. With the OPEC embargo cme the realization that oil would be scarse and so the only near term alternatives are coal and nuclear. The initial evaluations found that both the occupational and public health risks of coal were many times greater than the risks for nuclear reactors. Depending on the precise assumptions, coal was estimated to produce 100 to 10,000 times more adverse health effects than nuclear.

These initial analyses did not give adequate attention to various problems in both fuel cycles. For coal, environmental effects were not considered, including the health consequences of acid rain and the climate changes associated with atmospheric accumulation of carbon dioxide. For nuclear, inadequate attention was given to nuclear accidents, sabotage, the risks of nuclear proliferation, and disposal of radioactive waste. Later analyses have made some progress in considering these additional issues, but have tended to estimate the risks of coal and nuclear to be more comparable (Morris et al, 1980; Hamilton, 1980), with results shown in the table.

Dose -response relationships and the potential of future technology have generated intense controversy among the advocates of various technologies. The effect of low level ionizing radiation on health is generally assumed to be a linear, no threshold dose-response relationship, but there is no general agreement whether this relationship is correct of conservative (BEIR, 1971, 1980). The effects of sulfur oxides and suspended particulate matter on health have generated even greater controversy recently, with contradictory

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epidemiological studies, laboratory experiments that are difficult to interpret, and experts arriving at opposite conclusions about the health effects at current ambient levels (Lave and Seskin, 1977, 1979; National Academy of Sciences, 1978; Holland et al, 1979; Chappie and Lave, 1981). If the health effects of suspended particulate matter and sulfur oxides are dismissed or abatement technology is assumed to improve vastly, coal looks like a more acceptable alternative. I want to state my judgment that the health effects of sulfur oxides and particles are large and that stringent abatement is necessary.

The pitfalls of regulation are illustrated by coal. The 1971 EPA regulations covered sulfur dioxide and particles. The cheapest way of meeting the standard was to build a high stack to disperse the pollution over a wider area. There is a general consensus that acid sulfates, not sulfur dioxide, are the primary culprit in causing adverse health effects. The effect of a tall stack is to increase the amount of sulfur dioxide converted into sulfates generally and acid sulfates in particular. Thus, failure to get the regulations exactly correct helped lead to abatement policies which worsened the situation. EPA now requires stack gas scrubbers for all new coal fired plants. While these devices remove about 95 percent of the sulfur from the stack gas, they convert the remaining 10 percent to sulfates, particularly sulfuric acid mist. There are suggestions that scrubbers may have the effect of worsening health effects, at least locally.

More recent investigations have examined the risks associated with various solar technologies as well as of burning wood for home heating (Morris, 1981; Rowe and Groncki, 1980). Contrary to popular

belief that these energy sources are benign, they find that the health risks of photovoltaic technology and of wood burning are higher than those for coal. This is not an area where one's casual impressions can be relied upon.

Conclusion

I have sketched the difficulties in setting and implementing social goals and in performing quantitative risk analyses. In reviewing the health effects of various energy technologies, all investigators agree that nuclear appears to offer lower risks, generally significantly lower risks than coal. However, there is still vast uncertainty about various aspects of the fuel cycles and about technological changes in mining, abatement technology, and in waste disposal. Seemingly benign technologies such as photovoltaic and wood burning appear to offer a higher risk than coal, showing that alternatives have to be examined carefully.

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Table. Direct and systemwide occupational health risks of renewable energy technologies* and of coal and nuclear fuel cycles per 10^{12} Btu output

Technology	Labor	Illness & accidents		Fatalities	
	100 M-yr	WDL[a]	WDL/ 100 M-yr	10^{-5} Cases	Cases/ 100 M-yr
	Direct				
Central station photovoltaics	1.5	110	76	0.013	0.0086
Central station wind	1.1	120	120	0.0097	0.0090
Anaerobic sludge digestion	0.59	59	100	0.014	0.024
Wood pyrolysis	0.25	45	180	0.0018	0.0073
Passive solar heating	0.71	63	90	0.0081	0.011
Active solar heating	1.9	170	93	0.025	0.013
Active solar hot water	1.6	150	97	0.034	0.021
Active solar heating & cooling	2.5	220	88	0.031	0.013
Active solar process heat	1.6	150	94	0.021	0.013
Residential photovoltaics	8.1	610	75	0.11	0.013
Residential wind	6.4	800	120	0.053	0.0083
Residential wind with battery storage	7.8	790	100	0.062	0.0079
Coal-steam electric fuel-cycle	0.76	58	76	0.009	0.012
Nuclear fuel cycle	0.36	35	97	0.0054	0.015
	Systemwide				
Central station photovoltaics	3.27	270	85	0.038	0.012
Central station wind	2.3	240	100	0.028	0.012
Anaerobic sludge digestion	1.3	130	100	0.029	0.022
Wood pyrolysis	0.66	94	140	0.0094	0.014
Passive solar heating	1.7	160	95	0.028	0.016
Active solar heating	4.9	490	100	0.087	0.018
Active solar hot water	3.7	370	100	0.071	0.019
Active Solar Heating & cooling	6.6	640	97	0.11	0.016
Active solar process heat	3.8	380	98	0.062	0.016
Residential photovoltaics	20	1900	93	0.34	0.017
Residential wind	14	1500	110	0.16	0.012
Residential wind with battery storage	17	1100	99	0.201	0.012
Coal-steam electric fuel-cycle	1.9	170	89	0.032	0.017
Nuclear fuel cycle	1.1	120	110	0.025	0.022

*Source: Rowe, M.D. and P.J. Groncki, 1980. Occupational health and safety impacts of renewable energy sources. Supplementary report to Health and Environmental Effects of the National Energy Plan: A Critical Review of Some Selected Issues, (BNL 51300), Brookhaven National Laboratory. BNL 51307. 93 pp.

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Mr. FUQUA. Thank you.

Mr. SCHEUER. Before we go on to the next witness, I wonder if we could ask all of the witnesses, when they finish all of their testimony and we come to questions and answers, whether they would be prepared to give us a thoughtful, concise, finely tuned, and eloquent analysis of this morning's Supreme Court decision on risk and benefits. We have been floundering around with it. I talked to a few Members but we expect far better from you, and if you could give us the benefit of your thinking on it, each of you in your own ways, we would very much appreciate it.

Mr. FUQUA. Very good idea.

Dr. RAMSAY. My name is William Ramsay. I am a senior fellow in the Center for Energy Policy Research at Resources for the Future. Since Resources for the Future does not take a stand on policy issues, I want to emphasize that I am here at your invitation and these represent only my own views.

I anticipated that my friend, Lester, and my other colleague here might be explaining some of the more recondite aspects of risk analysis so I just thought that I would mention perhaps a few of the things that risk analysis cannot do. Now, I don't say this just to be a spoiler and to talk down risk analysis. Actually, I believe, just as in this latest OSHA controversy, that the failure to incorporate risk analysis adequately in the Federal Water Pollution Control Amendments of 1972 and the Clean Air Act Amendments of 1977 was quite tragic. We have certainly done a very great deal of research on resources in the future in our book, "Energy and America's Future," and so I am not certainly biased or by any means against risk analysis. But I think it's very important to understand why risk analysis—in the discussion that we had before our testimony—why there is this feeling of there being a difference between a social and political process and—it was phrased as—a technical kind of process, risk analysis.

I think if we understand some of the things that indeed Lester has referred to, some of the things that risk analysis can't do, we can understand what risk analysis may be able to do in the future or how we can explain to the public what kinds of roles risk analysis can and cannot have.

Now as Dr. Lave emphasized, one can put down the great difficulties in this field to uncertainties. And there are really three main categories of uncertainty. One is the uncertainty in the raw data. We just don't know what is going on in a lot of cases. As the discussion with Congressman Ritter pointed out, we don't know what the levels of carcinogens are a lot of times. The second thing is cause and effect. Again, going to carcinogens, we often don't know how much cancer is caused when by what substance. Then the third thing is a little more worrying and I call it sort of value judgments; I will go into that in a minute.

As far as problems with the raw data are concerned, well, we all know about the troubles in diagnosing how much air pollution actually occurs in certain plants. But there are also trickier things in the data in the sense that, even if we know what is happening nowadays, we have to look forward into the future and say, this is what is going to happen. In strip mining, we know a certain amount of strip mining is in the news and we know a certain

amount of what the consequences are of strip mining, but when we look in the future, we have to ask, what is the total risk to society. How much strip mining will there be? That depends how much coal is going to be produced, No. 1, and it also depends how much coal is going to be produced by strip mining versus underground mining. So there is a great problem there.

Again, when we talk about data difficulties, well, maybe Three Mile Island is one of the greatest problems there. I think all of a sudden the scientific and energy community found out that maybe they didn't know quite as much about data on nuclear safety as they thought they did. People have been saying, well, the public doesn't understand this and that about nuclear power and all of a sudden, the industry is saying, well, maybe the public wasn't so stupid after all, let's think it over again. So that is one possible problem.

The other problem I think is causes and effects. How do you get off causes and effects? Even if you know what radiation is, how do you know what the effect is on the body? I think some of you have followed in the news the latest controversy over the analysis of radiation at Hiroshima and how much health danger was really caused at Hiroshima.

Fortunately, Congressman McGrath talked about the situation where he doesn't want to use his constituents as guinea pigs. We have a lot of difficulty knowing how radiation affects people, very fortunately, because we don't want to go out and explode nuclear weapons to find out what the health results are.

Then there are particular aspects of causes and effects. Lester mentioned the railroad accidents when you ship coal. You have a railroad accident and, if there is coal in the train, you say that is the cost of shipping coal, you have killed somebody. It's not amusing, I suppose it's tragic—but if you look at the statistics on railroad crossing accidents you can see that a good number of them, say 20 to 25 percent of crossing accidents, are not trains running into cars but cars running into trains. Now you say if that car ran into a train, maybe that fellow was going to run into a telephone pole sometime, anyway, because he really wasn't watching things if the train was sitting there and he ran into it. OK? So you see it gets immensely complicated.

But it's hopeful in the sense that you talk about problems with human values and maybe we can see how we can really incorporate an approved risk analysis into all of our social decisions so we don't have phenomena like this Supreme Court decision that Mr. Scheuer referred to. For instance, is health or environment more important? Congressman McGrath referred to this concerning whether we take a risk of emissions of carcinogens or we take a risk of the garbage in the environment. That is a famous thing. Is a death, 1 death, worse than 10 cases of pneumonia from which people recover? Or 100 cases of chronic asthma?

These are questions that come up all of the time in these energy issues but there is really no way of resolving them without taking a poll of the public and finding out what they think. Different technologies, say coal and nuclear power, all have different ratios. Some cause more deaths, some cause more chronic illnesses. And I think the public realizes that—has a sense of that in many of these

different technologies. Perhaps we ought to listen to the public on some of these occasions.

Another area where we ought to find out what people really think has to do with catastrophes. I think it was referred to earlier by Mr. Walgren. He mentioned that we know that a certain amount of people will be killed in the coal mines every year. Well, we can pretty much say that, say, 200 people will be killed in the coal mines this year. How do we assess that risk versus the probability that some kind of great nuclear event or accident might kill 200,000 people? But it would probably only have 1 chance in a 1,000 every year. Now one way of looking at it is a very simple kind of risk analysis. You can say the expected number of people is 200 every year but it's a different kind of thing, and I think the public perceives that as being a different thing. And all of us in the field realize we have a lot to learn about attitudes in that area.

Finally, we have to look at equity considerations, which is what politics is all about. Consider technologies like some synthetic fuels processes that expose workers to carcinogens in the plants but which are relatively safe for the public. Are they better than technologies like ordinary burning of coal which may cause a great number of air pollution type diseases among the public? I mean there doesn't seem to be any easy way of answering that.

What do we do about future generations, if there is some truth to worries about nuclear waste? Most of the problems would be visited on our children, grandchildren, and progeny generation after generation. It's a famous conundrum, how do we treat those issues? Do we discount deaths when we get out there? If you look at most calculations people do, you will find that some kinds of deaths have to be discounted. Otherwise you will get some kind of energy technology that causes maybe 0.001 deaths every year, and if you add up over all of the years in the future, you will get a large number of deaths and say that's a terrible thing. You have to say, well, I am not going to worry so much about a death 2,000 years from now, as I am going to worry about a death today. I mean that's quite rational. On the other hand, a fellow 2,000 years from now, may have a different opinion about that.

I'm not trying to be obscurantist about this and say that we can't treat these issues, but I think that risk analysis is so necessary, as Lester has emphasized, if there's going to be reasonable legislation made and if we are going to have reasonable rules about work places and about effects of energy on the public. We just have to investigate these values. It would do us well to look at commonsense, to investigate, which indeed many social scientists have, as to why exactly people feel about nuclear power in a certain way. Why do they feel differently about hang gliding than they do about pollution from powerplants? This is not necessarily irrational behavior but this is the kind of stuff which really serious social science is made of. I think it's something that has to be taken into account.

Risk analysis is necessary. We have to be aware of its limitations and work very hard at the frontiers to try to explicate as much as we can about what kinds of risks are acceptable to what people, when and why and for what reason. Thank you.

[The prepared statement of Dr. Ramsay follows:]

STATEMENT OF DR. WILLIAM RAMSAY, RESOURCES FOR THE FUTURE, BEFORE THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY, JUNE 18, 1981, ON SOCIETAL RISKS OF ENERGY SYSTEMS

Introduction

Thank you Mr. Chairman for your invitation to testify before this committee. My name is William Ramsay. I am a Senior Fellow in the Center for Energy Policy Research at Resources for the Future, Inc. Resources for the Future is a non-profit tax-exempt organization whose purpose is to advance research and education in the development, conservation and use of natural resources, and as an institution does not take any stands on policy issues. I appear before your committee at your invitation, and my statement reflects only my own views.

I would like to discuss today some of the things that risk analysis cannot do, since the committee has heard and will hear a great deal of testimony about the many possibilities for the use of this valuable analytical tool in making sensible economic policy decisions. My views here do not reflect a bias against risk analysis. Indeed, I think a failure to include a consistent view of comparative risks represents one of the greatest defects in some existing legislation, such as the Federal Water Pollution Control Amendments of 1972, and, to some extent, the Clean Air Act Amendments of 1977. Rather, my remarks here reflect my fear that a failure of the scientific community to emphasize the built-in limitations of risk analysis might cause

premature public disillusionment with this technique, and a consequent worsening of the climate for rational energy policy decisions.

The main point to stress is that there are a great many uncertainities in the application of risk analysis. These uncertainties are in general of three kinds: inaccuracies in the raw data gathered on societal risks, ignorance about cause and effect mechanisms, and uncertainties about value judgements. All these sources of uncertainty may be significant in one or the other energy policy decision. The question of value differences, however, is perhaps the most serious and least tractable problem of all.

Uncertainties in Raw Data

The question of data measurement is notorious. Simply finding out what the level of carcinogens will be in, for example, a new coal synfuels plant is quite a difficult endeavor. Furthermore, it is difficult enough to measure certain pollutants at their source, but it may be an exceedingly tricky task to find out what the levels are at some later point in time and space. Even if we know what combination of pollutant compounds are released at a power plant smokestack, for example, we do not necessarily know what mixture of compounds they turn out to be after being carried long distances through the atmosphere, when they show up as dangers to the health, or--as in the case of acid rain--to the environment. When we do know something about present-day pollution patterns, we may run into trouble in not knowing what will happen in the future. For example, whatever it is that we know about the present effects of strip mining nowadays, it is still necessary to project into the future both how much coal will be produced in total and how much will be produced by surface mining--as opposed to underground mining. In

doing this, we must necessarily guess at what the total level of risk is.

One of the most famous recent examples may be Three Mile Island and the question of nuclear reactor accidents. As a result of Three Mile Island and the contemporaneous Lewis report, we realize we know much less about the probability of nuclear accidents than some had thought. And this bring up a point that I want to emphasize: the "uninformed" public may not always be wrong. That is, I believe that in some nuclear circles, the feeling had long been that the public was unaware of comparative risks and was unable to think rationally about tradeoffs between energy technologies. There is undoubtedly some truth to this proposition, but one might also bear in mind that the public may have a healthy skepticism about the general state of scientific knowledge on the risks of energy technologies, and of nuclear technology in particular.

Causes and Effects

Many times we can identify a pollutant released into the environment or we can delineate a general process like a strip mining operation, but we are still unable to connect it with specific impacts on health and environment. The problem in assessing the damages from Love Canal is a typical example. Or, increased growing of grains to produce fuel alcohols could impact on water pollution levels: but even if we measure the pollution, what is the net impact on the downstream environment? We have all also recently noted the reawakening of controversy about low-level radiation from nuclear power. These controversies had to do, not so much with the amounts of radiation emitted, but what that radiation actually did to the human body. And we are still a long way from understanding all of these phenomena.

Uncertainties in Values

It might be thought that we can go on improving our expertise in gathering raw data on health and environmental risks and in connecting that raw data with definite effects on the human body or on the Ecosystem--such as carcinogens from coal actually causing cancer in human beings, or certain amounts of strip mining actually leading to a loss of species variety in a particular environment. However, even if we can improve such knowledge, we still come up against the third and probably worst uncertainty: the question of discrepancies in values. First of all, suppose we have two different effects, one on health, and one on the environment (in the more restricted sense of ecosystems). According to risk analysis, which effect is more important? Even just considering such health problems by themselves, one has to consider whether such effects as fatal falls off roofs while installing solar collectors--surprisingly enough, possibly a not inconsiderable health risk, as these things go--are more important than chronic lung disease which may (or may not) be caused by or aggravated by emissions from coal-fired power plants. Are chronic diseases like asthma less serious than acute diseases like pneumonia? They probably are, but if so, how many asthma attacks are equivalent to one case of pneumonia?

What is the main importance of clean air? Is it in better visibility or in better health? If the answer is health, then why do the Clean Air Act Amendments of 1977 tend to put more pollution where pollution exists now, rather than spreading it around more evenly?

Incidentally, the difficulties in deciding such questions are no secret and I too have been guilty of giving them somewhat short shift at times. My book,

"Unpaid Costs of Electrical Energy: Health and Environmental Impacts from Coal and Nuclear Power" (Baltimore, MD., Johns Hopkins Press for Resources for the Future, 1979) discussed these value uncertainties. Nevertheless, I, as many others, have tended in my analyses to attach most importance to death rather than illness--even though one can note that death is inevitable but illness is not always so. Incidentally, one can go even further, and worry about at what time the death or illnesses are caused, as Milton Russell and I did in our paper, "Time-Adjusted Impacts from Energy Generation," Public Policy, vol. 26, no. 3 (Summer 1978).

The argument can become even more complex, but I must emphasize that these are complexities not for the sake of complexities but because they involve important human values about which the public probably possesses a greater depth of understanding than I believe some analysts have given them credit for. For example, there is the key question of the comparison of catastrophes with routine events. For instance, how do 200 coal miner deaths each year compare with 200,000 possible deaths from some sort of nuclear power impact spread out over a 1000 years? In other words, is there any difference between having a small chance of a large disaster or a large chance of a small disaster? How does the real acid rain problem, which though important, can probably be lived through, compare with the more hypothetical carbon dioxide accumulation problem, which could lead to serious worldwide environmental catastrophes?

Incidentally, I have my own personal value belief that the most dangerous effects from nuclear power is to have a nuclear weapon exploded over my head. And I mean that in a sense any of us are more likely from the risk-analytic point of view to experience "negative health effects" from the explosion of

a nuclear weapon than from any direct impacts from the operation of nuclear power plants. I emphasize that this does not mean that I think that the either of these effects is necessarily small.

Finally, there is the question of equity--or who's ox is gored. We have to ask ourselves whether it makes any difference if an energy technology visits most of its harm on workers, as opposed to members of the general public. This is possibly the case for the synfuels industry, where there may be some dangers to workers of carcinogenesis from compounds produced in the process of turning coal to fluids, but relatively little danger to the general public. Is this type of arrangement "fair"? A similar argument notes that city people are more exposed to air pollution than people in the country. In either case, of course one can say that there is some freedom to choose: presumably one does not have to take a dangerous job, and one does not have to live in a city if one fears the effects of bad air. On the other hand, I think we all realize that freedom of job and location choice, while great in America, is certainly not perfect.

Finally, what about fairness to future generations? We have traditionally most worried about this question in the context of nuclear wastes. While I personally am not a proponent of undue concern about nuclear wastes, nevertheless we can see that many impacts from nuclear waste could be visited not on us, but on future generations. One may ask of course, "What have future generations ever done for us?", a statement that is not quite as cynical as it may seem. Nevertheless, it seems to be within the human animal to harbor some feeling of responsibility for transmitting an environment as relatively clean as possible to those who follow us.

Conclusions

I have emphasized that risk analysis is a useful tool in making public policy decision. However, the role of key uncertainties--in data, cause and effect, and in human value judgements--must be recognized if risk analysis is to gain respect as a serious element in policy decision. In particular, one should take into account that some attitudes of the public, such as in many cases preferring routine risks to nonroutine risks, may not be truly "irrational" but may provide a clue as to how policy risk analysis should seek to incorporate human value preferences. In other words, much wisdom already resident in "common sense"--that uncommon quantity--must be combined with the scientific advances in the field of quantitative evaluation of risks if risk analysis is to become a widely accepted and useful device for helping develop future energy policy.

Mr. FUQUA. Thank you, sir. Dr. Richmond?

Dr. RICHMOND. Thank you. My name is Chester Richmond, I am associate laboratory director in charge for biomedical and environmental sciences at Oak Ridge National Laboratory. I would like to start off by mentioning something quoted by a visitor to the Oak Ridge area recently.

"Never in history has society been confronted with a power so full of potential danger and at the same time so full of promise for the future of man and the peace of the world."

This was in context of the internal combustion engine and congressional hearings in 1875.

I compliment you on these hearings, my point is that things are not new. Perception of a need for more comprehensive risk analysis is new.

I am going to read and cover some of the highlights of my testimony. I prepared the testimony not just for the committee, but for visitors, and I hope it is of use since it is rather comprehensive for people attending the hearings.

I believe these hearings reflect society's broad interest in production, distribution, utilization, and disposal of materials which at some point in their lifecycle may cause more harm than benefit to man.

The materials may interact directly with living systems, or indirectly via intricate and only partially understood mechanisms. There is much to be learned as to how these many materials, be they from energy producing or other technologies, ultimately affect man.

I believe risk analysis will be a challenge to many of us during this decade, and I would like to share with you some of my thoughts as to why I believe this.

The 1970's are now being viewed as the decade of environmental and health legislation. Figure 1 on page 4 of my prepared testimony plots significant items of environmental and health legislation from about 1935 through the late 1970's. It is very clear that there

was an explosion of legislation related to health and environmental issues following the passage of the National Environmental Policy Act as we entered the 1970's.

Indeed, 1970 was a bumper year with three significant pieces of legislation. I would particularly like to call your attention to 1976, the year in which the Resource Conservation Recovery Act [RCRA] and the Toxic Substance Control Act [TSCA] were passed.

RCRA is important due to its relationship to land burial of materials. Legislation dealing with release of materials to the air and water had been established prior to the passage of RCRA. Because there are only three places to place materials—air, water, and land—RCRA became a forcing function in the sense that everything must go somewhere.

I predict that the 1980's will be a decade in which there will be much collaboration, cooperation, and, indeed, compromise between the developing technologies and the so-called environmental movement. This may be the major challenge to the scientific community during the 1980's.

There will be demands from many quarters of the scientific and other communities to determine whether or not individual or classes of compounds are hazardous or toxic or carcinogenic or mutagenic, and to what extent these materials may be detrimental to man. There will be many pressures and inquiries from the public, Federal and State agencies, and private-interest groups.

We must resist the temptation to provide quick answers to very complex problems, and above all, we must do good science and be intolerant of those who ignore the time-honored scientific processes. We must also realize that policy judgments pointed out earlier must often be made before all the results may be collected.

In these cases we must contribute to the required analyses and assessments, especially in the health and environmental area, so that input to decisionmakers represents the best available interpretation of the available data. I think that is a very important point.

I believe we must all become part of that process so that we may bring new technologies on line at the least societal cost.

It was mentioned before there is no benign system for producing energy. If anyone tells you there is, they are lying to you. We must recognize that technological development and the protection of individuals in the work place and society are not incompatible goals, and we must help break down the barriers between the life and environmental scientists and the technologists, who often in the past have appeared to be adversaries.

As an example of this attitude, there is a growing recognition within industry and public interest groups that health, safety, and environmental issues must be integrated into the initial state of plant design. Industry is becoming much more tolerant of the notion of incorporating design changes to prevent adverse environmental or health impacts. Everyone benefits if the necessary changes are identified as early as possible in the development or demonstration process.

I and others believe that risk analysis is the tool which will allow us to begin to solve many of the problems alluded to above. There is rapidly growing interest in risk analysis in the scientific and other disciplines. I would like to spend several minutes as request-

ed by the group on one example of the emergency of an interdisciplinary professional field of risk analysis--that is, the newly created Society for Risk Analysis which was formed as the direct result of scientists from the United States and abroad recognizing the need for such a professional organization.

I believe it is also significant that some of the founders of the Society for Risk Analysis, the Steering Committee, are members of Federal regulatory agencies. The day-to-day requirements of their jobs, in my opinion, probably led to the need for a professional group of individuals interested in risk assessment and its application.

The official publication of the Society is Risk Analysis—An International Journal. It will be published quarterly. Included will be research papers, review articles, editorials, book reviews, letters, and announcements.

We have had people ask, Why do risk analysis? There are several reasons for studying risk, but perhaps the broadest statement is to enable decisionmakers and the public to make the right choices in terms of dangers to human health and the environment. There is a further reason for studying risk more.

Somebody somewhere is doing their own risk analyses and not always rationally. Although much of the work has been done in the United States, other countries have also generated studies. An analysis done at the ORNL Information Center Complex produced over 500 references on risk from 21 countries. Most have been published in the last 5 years.

I thought I would pick two examples not from the United States, but how other parts of the world view the situation. One was done by Sir Edward Pochin, of the United Kingdom. It appeared in Physics in Technology last year.

Sir Edward Pochin points out that statements of harm, even for death, are uncertain and imcomplete and much more work is needed. Still, it appears that approximate estimates can be obtained, and these are likely to differ by factors of up to 60 for different major fuel sources. The largest risk was 10 to 15 deaths per year in a population of 1 or 2 million people deriving electricity from coal.

He normalizes his effects to one gigawatt year output, roughly enough power for 1 to 2 million people. In decreasing order, he found about 10 deaths from oil, 7 from hydroelectric, 2 from nuclear and 0.25 from natural gas. The ranges of the estimates are large and in some cases increased with the number of deaths—for example, about 9 to 40 for coal.

For the population in question, I think this is important—1 to 2 million people—there would be 450 to 900 deaths from all accidental causes and 12,000 to 24,000 deaths from all causes. He points out the difficulties in assessing proper significance to radionuclides such as ^{14}C and ^{129}I which can deliver low doses of radiation to the world population for a very long time.

Dr. Ramsay alluded to this before, how do you account for effects that may account for long periods of the future. Similarly, Pochin mentions that additional harm to future generations from a progressive buildup of carbon dioxide in the atmosphere is difficult to assess.

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Depending on the major systems, they have these large uncertainties. I have one other example in the prepared testimony I won't get into now from the United Kingdom.

Mr. FUQUA. Dr. Richmond, I hate to interrupt you. We have a rollcall vote and we are going to have to recess for a few minutes and then come right back so we can resume. I apologize for the interruption. That is part of the risk of our job. [Laughter.]

Dr. RICHMOND. I hope the benefits are comparable.

Mr. FUQUA. We will stand in recess for a few moments and we will be right back.

[Recess.]

Mr. FUQUA. The hearing will resume and Dr. Richmond, you may resume your testimony.

Dr. RICHMOND. Thank you. I would, in the interest of time, like to move on now to mention some of the programs that are being conducted by various Federal agencies.

One of the major ones is that of the Department of Energy environmental assessment program called the HERAP program. I think this is a very interesting one. It is a component of the Office of Energy Research within DOE.

The program managers of the HERAP have very close contact with environmental research personnel, this helps because the assessment activities get closely coupled and coordinated by research efforts. The assessments themselves draw on available knowledge and are not limited to just the DOE-supported research results. We had a question earlier from one of the members of the committee about how do you tranfer information among agencies and this is a successful example since there are interactions with the HERAP personnel and the Environmental Protection Agency programs.

In addition to providing a continuing and iterative process of integrating research results in a coherent method, the HERAP provides the essential opportunity to assist research managers within OHER identify research gaps, and thereby establish research priorities. Risk analysis, therefore, allows one to produce more than the typical litany of research needs. It permits one to estimate the specific contributions that research efforts will make toward understanding the risk of a specific technology.

I would like to move on now to some of the international activities and only home in on one. The international symposium sponsored by the International Atomic Energy Agency, the United Nations Environment Program, and the World Health Organization, will be held beginning next Monday. On the program will be many people interested in risk analysis, including the science advisor to Senator Howard Baker.

It turns out there are 41 countries including the People's Republic of China who will be represented at the meeting, and 8 individual international organizations. It's obvious that international boundaries have little meaning for materials produced and released by man. Two cases in point are the atmospheric CO_2 and acid deposition. I think it is quite obvious that more cooperative risk studies among nations will need to be done in the 1980's.

I would like to close with a brief discussion on what I view as further needs in risk analysis. The integrative component of the comprehensive health studies risk analysis also integrates all of

the uncertainties associated with determining exposures and hazards. Thus, I believe it will advance in general as basic knowledge accumulates.

However, progress may be served if basic research were included in the methods.

The major role of risk analysis at present is to identify and prioritize data/research needs within a consistent and comprehensive framework. This role is of major importance but has not been utilized enough or consistently.

It is not easy to determine what national needs are in terms of risk analysis, because no one single body directs and funds this research. However, we can gain some idea from a series of questions—slightly altered here—that were posed by the Technology and Assessment Group of the National Science Foundation:

These are:

One. How do we determine how safe is safe enough?

Two. How good are the data on which we depend for estimates of risk?

Three. How are estimates of risk translated into decisionmaking?

Four. How should we deal with uncertainty?

Five. What should institutions do when confronted with risk uncertainty?

Six. We heard this before: How do we perceive risk?

Seven. Do individual perceptions of risk add up to a total view of society, that is, does the whole equal the sum of the parts?

And lastly, are some risks unacceptable, regardless of the accompanying benefits?

Another indication of possible national needs was given in the bill introduced by Congressman Ritter of Pennsylvania. This bill, designed to be cited as the Risk Analysis Research and Development Act of 1981, is in my opinion, an important and necessary piece of legislation.

The broad statements made in both the National Science Foundation document and Congressman Ritter's bill suggest the need for a strong scientific basis for risk analysis. Some of that foundation has already been laid, but there is considerable work to be done.

In particular, there is need to: (a) Develop the basic theory and methods; (b) support the experimental determination of risk-related data; (c) study risk perception and decision analysis; and, most important of all, get on with it and do the actual risk assessments.

Without the methodology, no overall risk assessment can be constructed. It is clear that improving the methodology will require advances in mathematical techniques.

The data are also a key component of the final risk assessment. In some cases, much of the data in the field are either only vaguely known or in dispute, so there is considerable room for improvement.

In closing, I would like to give one example of how I think we have already shown the benefit of risk analysis. The laboratory at Oak Ridge and other laboratories have been looking at potential health and environmental impacts of synthetic fuel technologies, specifically converting coal into oil and gas or getting oil from shale.

Part of that research is linked to risk analysis programs. The individuals found that many of the compounds that one produces when you convert coal that are potentially mutagenic (that is can cause genetic damage) or carcinogenic, can cause cancer if released to the public. These compounds can be biologically and chemically characterized and design changes can be made early enough to reduce the biological damage observed in test systems.

This has been done through hydro treatment and I think it is a classic example of our research community working in the framework of risk analysis has provided feedback into the developing technology early enough so that the technology could be altered.

Previously, much of the life sciences input, be it environmental or health, has come at the licensing stage and very often has been more of a roadblock than an assist in getting the technologies developed to where, as I said earlier, they provide more benefit than detriment to society.

Thank you.

[The prepared statement of Dr. Richmond follows:]

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TESTIMONY PRESENTED TO THE HOUSE SCIENCE AND TECHNOLOGY COMMITTEE

18 JUNE 1981
WASHINGTON, D.C.

Chester R. Richmond
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Biomedical and Environmental Sciences

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Operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

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ABSTRACT

This report is the text of invited testimony given by the author before the House Science and Technology Committee. This Congressional hearing on Societal Risks of Energy Systems reflects the growing interest on the part of Congress, the public, the scientific community, and other groups on this extremely important topic of Risk Analysis. This presentation will contain information on the emergence of an interdisciplinary professional field of risk analysis, including the recently formed Society for Risk Analysis. I will also discuss in some detail various risk analysis programs now in progress at the Oak Ridge National Laboratory and other research institutions. Also included will be some general philosophy concerning risks from energy-producing systems and my perspective on the needs for further developments in the field of risk analysis.

TESTIMONY PRESENTED TO THE
HOUSE SCIENCE AND TECHNOLOGY COMMITTEE

Chester R. Richmond

I. Introduction

Mr. Chairman, Panel Members, Ladies and Gentlemen:

My name is Chester R. Richmond. I am Associate Laboratory Director for Biomedical and Environmental Sciences at the Oak Ridge National Laboratory (ORNL) which, as you know, is one of the major multipurpose scientific research and development institutions operated by various private contractors for the U.S. Department of Energy. As Director of a large Biomedical and Environmental program, I have had the opportunity to personally participate in the planning and implementation of health, safety, and environmental research related to both conventional and developing energy-producing technologies. My colleagues and I, together with individuals from other Federally supported laboratories, academic institutions, numerous Federal agencies, and private organizations, have participated in the planning and implementation of a life sciences program in support of energy-producing technologies including materials obtained from coal or shale. In this context, I had the privilege of participating in hearings held by this Committee in September 1979 on the subject of Health and Environmental Considerations for Synthetic Fuel Technologies.

My colleagues and I have also been very much involved in the rapidly evolving field of risk analysis. I think this is a natural outgrowth of concerns expressed by many individuals in the research, academic, public, and other sectors that there must be better approaches to finding answers to questions of whether a technological system under development might provide more benefit than detriment to society.

I also had the privilege of testifying before this Committee's Subcommittee on Environment and the Atmosphere in March 1976. Those hearings, conducted by the Honorable George E. Brown, Jr., were very timely because of the growing interest both in Congress and throughout the United States and the world concerning the magnitude of

health effects associated with exposure to low levels of pollutants and the attendant societal costs. Those hearings on the Effects and Costs of Long-Term Exposure to Low Levels of Man-Made Pollutants and similar hearings argue strongly for the use of risk analysis.

I am also a member of the International Commission on Radiological Protection's (ICRP) Committee 2 on Secondary Limits. I mention this because the ICRP has recently restructured its primary radiation protection philosophy on the basis of risk to specific body organs and a comparison of radiation risks to risks that exist for workers in other occupations.

I am a charter member of the recently formed Society for Risk Analysis. I have served as a member of the Steering Committee which worked for over a year to establish the Society.

Last October I served as Chairman of a symposium on Health Risk Analysis which probed the health aspects of risk analysis in some detail. The proceedings of this symposium are being published by Franklin Institute Press. I am also serving as Scientific Adviser to the Department of Energy for an international symposium to be held next week here in the United States on the subject of Health Impacts of Different Sources of Energy. This meeting will be sponsored by the World Health Organization, The United Nations Environment Program, and the International Atomic Energy Agency in cooperation with the U.S. Department of Energy and the Oak Ridge National Laboratory.

I have also participated in various symposia and workshops related to risk assessments and risk analysis. I might mention one in particular; that is, the Symposium/Workshop on Nuclear and Non-Nuclear Energy Systems: Risk Assessment and Government Decision Making, held in 1979 by the MITRE Corporation, because both of my colleagues on this panel also participated in that workshop.

I welcome the opportunity to participate in this hearing. The timing is especially important since the Nation is struggling to understand and live with a great deal of health, energy, and environmental legislation inherited from the 1970's.

II. Emergence of an Interdisciplinary Professional Field of Risk Analysis

I believe these hearings reflect society's broad interest in the production, distribution, utilization, and disposal of materials which at some point in the life cycle may cause more detriment than benefit to man. The materials may interact directly with living systems, or indirectly via intricate and only partially understood mechanisms. There is much to be learned as to how these many materials, be they from energy producing or other technologies, ultimately affect man.

I believe risk analysis will be a challenge to many of us during this decade, and I would like to share with you some of my thoughts as to why I believe this. The 1970's are now being viewed as the decade of environmental and health legislation. Figure 1 plots significant items of environmental and health legislation from about 1935 through the late 1970's. It is clear that there was an explosion of legislation related to health and environmental issues following the passage of the National Environmental Policy Act as we entered the 1970's. The year 1970 was a bumper year with three significant pieces of legislation. The year 1972 was also busy, with four major pieces of legislation. I would particularly like to call your attention to 1976, the year in which the Resource Conservation Recovery Act (RCRA) and the Toxic Substances Control Act (TSCA) were passed.

RCRA is important due to its relationship to land burial of materials. Legislation dealing with release of materials to the air and water had been established prior to the passage of RCRA. Because there are only three places for materials to go — air, water, and land — RCRA became a forcing function in the sense that everything must go somewhere. Perhaps an example is in order. If we remove sulfur and other materials from the stacks at power plants, we must then grapple with the question of where we place the collected materials that otherwise would have been dispersed through the air to

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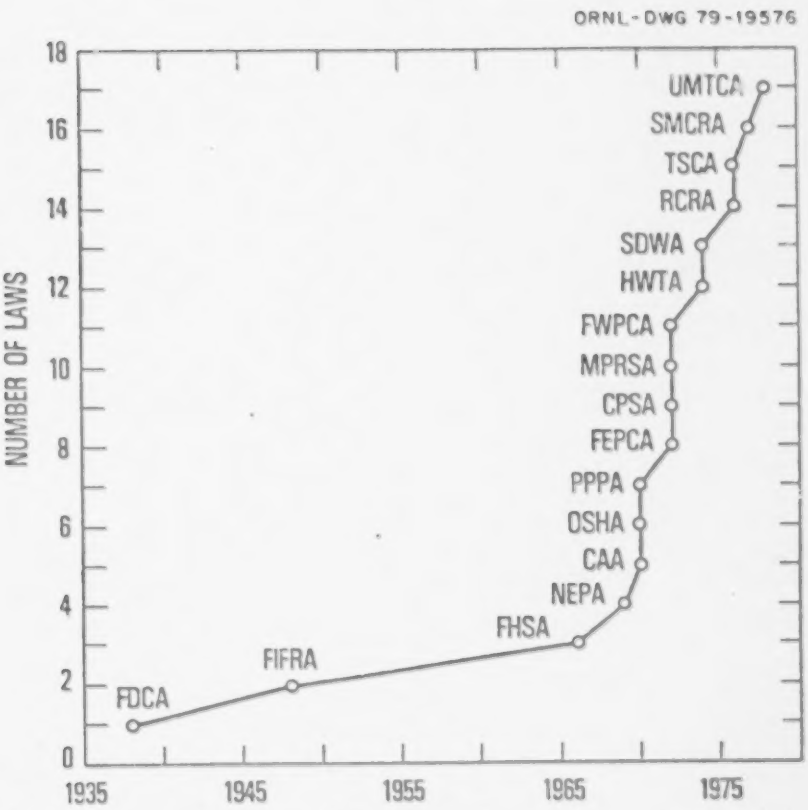

FDCA	–	Federal Drug and Cosmetics (1938)
FIFRA	–	Federal Insecticide, Fungicide, and Rodenticide (1948, 1972, 1975)
FHSA	–	Federal Hazardous Substances (1966)
NEPA	–	National Environmental Policy (1969)
PPPA	–	Poisonious Packaging Prevention (1970)
OSHA	–	Occupational Safety and Health (1970)
CAA	–	Clean Air (1970, 1977)
FWPCA	–	Federal Water Pollution Control (now Clean Water) (1972, 1977)
MPRSA	–	Marine Protection, Research, and Sanctuaries (1972)
CPSA	–	Consumer Product Safety (1972)
FEPCA	–	Federal Environmental Pollution Control (1972)
SDWA	–	Safe Drinking Water (1974, 1977)
HMTA	–	Hazardous Materials Transportation (1974)
RCRA	–	Resource Conservation and Recovery (1976, 1979)
TSCA	–	Toxic Substance Control (1976)
SMCRA	–	Surface Mine Control and Reclamation (1977)
UMTCA	–	Uranium Mill Tailings Control (1978)

Fig. 1. Health and Environmental Protection Laws

other locations. In a sense, we are trading between the dispersion of a material from its source to the concentration of the material at its source. Material collected by control technology systems are often "disposed of" by land burial.

I predict that the 1980's will be a decade in which there will be much collaboration, cooperation, and, indeed, compromise between the developing technologies and the so-called environmental movement. This may be one of the major challenges to the scientific community during the 1980's. There will be demands from many quarters of the scientific and other communities to determine whether or not individual or classes of compounds are hazardous or toxic or carcinogenic or mutagenic, and to what extent these materials may be detrimental to man. There will be many pressures and inquiries from the public, Federal and state agencies, and private interest groups. We must resist the temptation to provide quick answers to very complex problems, and above all, we must do good science and be intolerant of those who ignore the time-honored scientific processes. We must also realize that policy judgments must often be made before all the results may be collected. In these cases we must contribute to the required analyses and assessments, especially in the health and environmental area, so that input to decision makers represents the best available interpretation of the available data. The limitations and uncertainties of the information must also be clearly communicated to the decision makers. This is an enormous challenge and one which we must accept if there is to be a sound, comprehensive basis for decision making. I believe we must all become part of that process so that we may bring new technologies on line at the least societal cost. We must recognize that technological development and the protection of individuals in the work place and society are not incompatible goals, and we must help break down the barriers between the life and environmental scientists and the technologists, who often in the past have appeared to be adversaries.

Some individuals have expressed a concern that the environmental movement may be severely crippled or destroyed during the 1980's. Although I believe that the recent momentum of the movement will be slowed and that directions may be altered, I think most of you would join me in hoping that the advances and attitudinal changes that were made in the 1970's are not totally reversed. We as a society cannot afford to destroy the gains that were made. As I indicated earlier, we must work together to foster an attitude of collaboration, cooperation, and, where necessary, compromise among all the players. As an example of this attitude, there is a growing recognition within industry and public interest groups that health, safety, and environmental issues must be integrated into the initial state of plant design. Industry is becoming more tolerant of the notion of incorporating design changes to prevent adverse environmental or health impacts. Everyone benefits if the necessary changes are identified as early as possible in the development or demonstration process.

I and others believe that risk analysis is the tool which will allow us to begin to solve many of the problems alluded to above. There is rapidly growing interest in risk analysis in the scientific and other disciplines. I would like to spend several minutes expanding on one example of the emergence of an interdisciplinary professional field of risk analysis — that is, the newly created Society for Risk Analysis which was formed as the direct result of scientists from the United States and abroad recognizing the need for such a professional organization. I believe it is also significant that some of the founders of the Society for Risk Analysis, the Steering Committee, are members of Federal regulatory agencies. The day-to-day requirements of their jobs, in my opinion, probably led to the need for a professional group of individuals interested in risk analysis and its applications. A list of the Steering Committee members is included in Appendix 1.

The official publication of the Society is "Risk Analysis — An International Journal." It will be published quarterly by Plenum Publishing Corporation. Included will be research papers, review articles, editorials, book reviews, letters, and announcements.

The Journal will provide a focal point for new developments in risk analysis for scientists from a wide range of disciplines and cover topics of considerable interest to regulators, researchers, and scientific administrators. It will deal with health risks, engineering risks, mathematical and theoretical aspects of risks, and with the social and psychological aspects such as risk perception, acceptability, ethics, and economics. The scientific articles in the Journal will be peer reviewed.

Earlier this month the Society for Risk Analysis, the World Health Organization and the Assembly for Behavioral and Social Sciences, and the Assembly for Life Sciences (Board on Toxicology and Environmental Health Hazards) of the National Academy of Sciences/National Research Council jointly sponsored an international workshop on the analysis of actual versus perceived risks. Several sessions of the program were related to energy production.

III. General Comments on Risk Analysis and Energy-Producing Systems

There are many possible reasons for studying risk, but perhaps the broadest statement is to enable decision-makers and the public to make the right choices in terms of dangers to human health or the environment. There is a further reason for evaluating risk scientifically; whether or not the subject is studied in the laboratories, somebody somewhere is doing their own crude risk analysis — not always rationally.

There are other less general purposes in studying risk. Some of the reasons, in no particular order, which have been suggested are:

- o Recent government-wide guidelines will require that risks be balanced against benefits for many future regulations.
- o Its study will provide information needed to make decisions on health and environmental standards.
- o Using risk analysis will allow scientists and engineers to identify gaps in knowledge.
- o Risk studies can measure the real health and environmental benefits of proposed controls.
- o In terms of energy systems, they would help the public to understand the non-monetary choices which have to be made.
- o It allows risks which are deemed unacceptable by some to be identified and perhaps reduced.

Although much of the work has been done in the United States, other countries have also generated studies. An analysis done at the ORNL Information Center Complex produced over 500 references on risk, from 21 countries. Most have been published in the last five years.

I would now like to briefly touch on risk from energy-producing technologies. It is important to incorporate all phases of the fuel cycle including supporting industries and storage systems in the analysis. We also need to remember that the further away a technology is from demonstration, the more benign it may appear

simply because we do not know enough information. Lastly, we need to state uncertainties in the data and highlight areas where data are missing or estimated.

The 1964 United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) study was among the first reasonably comprehensive risk studies. Since then many have appeared in journals and books. A partial listing of some additional risk studies is given in Table I.

Table I. Selective Listing of Risk Studies on Energy Systems

o The 1969 Starr paper
o The 1969 Doll study in Britain
o The 1974–5 WASH–1400 report by the U.S. Atomic Energy Commission
o The 1975 Pochin study comparing five energy sources
o The 1977 International Commission on Radiological Protection
o A 1980 U.S. Committee on Nuclear and Alternate Energy Systems report
o The 1979 British Canvey Island Study
o The 1980 German Risk Study, paralleling WASH–1400
o A 1978 Canadian Atomic Energy Control Board study
o A 1979 U.S. document (the "Lewis report") evaluating WASH–1400
o The 1981 NRC document on index of risk exposure

A current example of comparative energy risk study by E. E. Pochin (Physics in Technology 11: 93—8, 1980) is entitled "Biological Risk Involved in Power Production." Pochin points out that estimates of harm, even for death, are uncertain and incomplete and much more work is needed. Still, it appears that approximate estimates can be obtained, and these are likely to differ by factors of up to sixty for different major fuel sources. The largest risk was 10—15 deaths per year in a population of one or two million people deriving electricity from coal. Pochin normalizes his effects

to one GW(e) year output (power for one to two million people). In decreasing order, he found about ten deaths from oil, seven from hydroelectric, two from nuclear, and 0.25 from natural gas. The ranges of the estimates increased with the number of deaths (e.g., about nine to forty for coal).

For the population in question (one to two million people) there would be 450-900 deaths from all accidental causes and 12,000 to 24,000 deaths from all causes. He points out the difficulties in assessing proper significance to radionuclides such as ^{14}C and ^{129}I which can deliver low doses of radiation to the world population for very long times. Similarly, he mentions that additional harm to future generations from a progressive build-up of carbon dioxide in the atmosphere is difficult to assess.

Another recent comparative study is worth mentioning. This one was produced by A. V. Cohen and D. K. Pritchard of the British Health and Safety Executive (Comparative Risks of Electricity Production Systems: A Critical Survey of the Literature, Research Paper II, HM Stationery Office, London L2, England). They studied the international experience of safety for the complete fuel cycle of each system. They found that the nuclear system involved no more and probably less risk to the public than oil- or coal-burning systems for producing electricity. Cohen and Pritchard based their findings on 87 studies produced prior to May 1980. Because risk estimates for unconventional alternative systems which are not developed beyond the prototype stage were too speculative for comparison, they concentrated on oil, coal, and nuclear (mostly light water reactors) fuel cycles.

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IV. Risk Analysis Programs at the Oak Ridge National Laboratory and Other Research Institutions

Risk Studies at the Oak Ridge National Laboratory

A wide variety of risk-related activities now take place at ORNL. It is not the object of this section to list all of them in detail.

Risk analysis studies at ORNL include energy system analysis under normal and accident conditions. Research has estimated the probabilities of undesired events and attempted to ensure that target probabilities are not exceeded. Methods are being developed to evaluate reactor designs; mathematical fault trees are being formulated to determine the risk of these designs due to common cause events. Techniques are being developed to identify and reduce risks associated with human factors — in particular, nuclear power plant operators.

ORNL staff have much experience in preparing environmental impact statements for a wide range of energy-related projects. Some of the information in these statements can be used in risk assessments. The amounts of potentially harmful materials, their transport and what happens to them, ecological effects, biological pathways to man, and probable health effects are being analyzed by ORNL staff. Environmental assessments also deal with resource availability, aesthetics, and ecological integrity.

ORNL is an internationally recognized center of expertise in mathematical modelling of environmental and health effects of energy-related pollutants. Comparative "dose conversion" factors for a given quantity of radiation or chemical are being developed. For over 30 years, ORNL has served as the principal developer and reference source for models and techniques to estimate radiation doses received by humans. Most nations have uniformly adopted the ORNL models and techniques through the recommendations of the International Commission on Radiological Protection.

The Laboratory has experience in comparative risk assessments of different energy technologies. Several comparisons have been made of

the risks of generating electricity from coal and nuclear fuels. A new staff member, Dr. H. Inhaber, has analyzed the human health risks of the entire fuel cycles of conventional and non-conventional energy systems.

As mentioned above, there are less immediately obvious aspects of risk. The social, economic, and psychological considerations necessary to set numerical risk criteria are being studied under ORNL sponsorship.

The seven major categories for risk analysis or assessment work at ORNL are as follows:

- o energy system analysis, primarily nuclear, including reliability, as well as human factors, environmental impact statements, and safety and security analysis;
- o basic data generation and collection and evaluation of data, including much biological research, as well as information and data centers;
- o risk-benefit assessments, primarily non-nuclear, including financial and strategic risk, socio-economic impacts, and related topics;
- o comparative risk assessments;
- o perception of risk; and
- o decision analysis and mathematical methods and models.

Some examples of specific risk analyses now being performed at ORNL are as follows:

- o health risks of high voltage transmission lines;
- o health and safety impacts of eastern oil shale development;
- o environmental and health impacts associated with solid fuels as residential heat sources;
- o health and safety issues associated with combustion of toxic substances in high temperature incinerators;
- o National Environmental Policy Act related documents for uranium mill tailings;

- o Health and safety analyses of biomass energy.
- o public and occupational health effects of direct and indirect coal liquefaction and oil shale; and
- o occupational risk and injury assessment of conventional and emerging energy technologies.

Organizations Performing Risk Analysis and Assessment Work

It is perhaps more difficult to identify the present major centers of activity in risk analysis. Some which come to mind, to give some idea of the kinds of organizations, are:

- o the DOE National Laboratories, primarily ORNL and Brookhaven;
- o MITRE Corporation;
- o NUS Corporation;
- o ISPRA Research Center in Italy;
- o the British Health and Safety Executive;
- o the U.S. Nuclear Regulatory Commission;
- o the U.S. Environmental Protection Agency;
- o Kraftwerke Union in the Federal Republic of Germany;
- o George Washington University;
- o Atomic Energy of Canada Limited in Canada;
- o the U.S. Office of Technology Assessment;
- o Massachusetts Institute of Technology;
- o Harvard University;
- o University of California at Los Angeles
- o University of California, Berkeley;
- o Decision Research, Inc. (Oregon);
- o Science Applications, Inc.;
- o General Atomics, Inc.;
- o Resources for the Future;
- o J. H. Wiggins Co.;
- o Brookings Institute
- o Clark University;
- o New York University; and
- o Franklin Pierce Law Center.

While it is difficult to estimate which of these has the largest number of personnel studying risk, it likely would be the National Laboratories, the NRC, and the British Health and Safety Executive. Some are small groups of six or fewer people.

Department of Energy's Health and Environmental Assessment Program (HERAP)

The Department of Energy's Health and Environmental Assessment Program (HERAP) is a part of the Office of Health and Environmental Research (OHER), which is a component of the Office of Energy Research. As an integral part of OHER, HERAP draws directly on DOE health and environmental research efforts. DOE/HERAP program managers have close contact with contractor health and environmental research program personnel, because assessment activities are closely coupled and coordinated with research efforts. The assessments themselves draw on all available knowledge and are not limited to DOE-supported research results. HERAP activities are also closely meshed with other assessment efforts at both the national and international levels. There have been, to list a few, participations with the Department of State, the Environmental Protection Agency, the Office of Technology Assessment within the U.S., and on a broader scale, the United Nations Environment Program and the Organization for Economic Cooperation and Development.

In addition to providing a continuing and iterative process of integrating research results in a coherent method, the HERAP provides the essential opportunity to assist research managers within OHER identify research gaps, and thereby establish research priorities. Risk analysis, therefore, allows one to produce more than the typical litany of research needs. It permits one to estimate the specific contributions that research efforts will make toward understanding the risk of a specific technology.

The objective of the HERAP is to improve the basis for decisions throughout the Department of Energy by providing quantitative, analytical descriptions based on current information of knowledge and

uncertainty regarding the nature and magnitude of the potential health and ecological impacts of installing, operating, and decommissioning energy technologies. The approach used is to initiate continuing analytical efforts at a level of three to five person years per year to identify and evaluate the technical information relevant to describing the nature and magnitude of potential health and ecological impacts of energy technologies and to provide periodically a health and environmental effects document which presents the understanding of such impacts at that point in time. It is planned that this will be an iterative process. Efforts underway are planned or grouped into three categories:

(1) methodology development;
(2) generic analyses; and
(3) specific energy technologies.

The HERAP activities and contractors are shown in the following Table II.

Table II. Major Components of Department of Energy's Health and Environmental Assessment Program (HERAP)

Title	Contractor
Methodology Development	
Analyses of Dose Response	University of California – Davis
Hydrocarbon Carcinogenicity	Harvard University
Health Indicators	Brookhaven National Laboratory
Risk Analysis Methodologies	University of Maryland
Generic Analyses	
Waterborne Hydrocarbons	MITRE Corporation
Airborne Particles	Harvard University
Nitrogen Oxides	Brookhaven National Laboratory
Specific Energy Technologies	
Comparative Impacts	Brookhaven National Laboratory
Battery Systems	Argonne National Laboratory
Diesels	Inhalation Toxicology Research Institute
Photovoltaics	Brookhaven National Laboratory
Oil Shale	IWG Corporation
Coal Liquefaction H-Coal	Oak Ridge National Laboratory
Coal Liquefaction SRC-II	To be assigned
Coal Gasification	Argonne National Laboratory
Space Nuclear Systems	University of California – Davis
Municipal Waste Combusion	Ames Laboratory
Fluidized Bed Combustion	Inhalation Toxicology Research Institute
Geothermal	Lawrence Livermore National Laboratory
Fusion	to be assigned
Indoor Air Quality	to be assigned

The underlying challenge proposed by this activity is to converge current scientific data with analyses of developing technologies. Much of the data is missing and many paramaters used in the analyses contain much variability. Currently the health portions of the analyses are thought to contain the greatest uncertainties and, therefore, require the most attention. We need to remind ourselves periodically that despite the uncertainties a well-conducted risk analysis represents our best attempt to summarize what is known and what is not known of the risks of a given developing or established technology.

Environmental Protection Agency Risk Programs

At least seven major Federal acts (Toxic Substances Control Act, Clean Air Act, Federal Water Pollution Control Act, Safe Drinking Water Act, Federal Insecticide, Fungicide and Rodenticide Act, and Resource Recovery and Conservation Act) mandate the Environmental Protection Agency to control substances that are harmful to human health and the environment. The control of substances is based upon health and environmental risk assessments varying from single chemicals to chemical ranking systems to technology-wide applications.

The Office of Health and Environmental Assessment provides overall assessment support to other EPA offices implementing the mandates of the laws. The objective is to enhance the risk assessment capabilities within the Agency and develop scientific criteria concerning the effects of pollutants on ecosystems and human health. Initial risk assessment activities stress the development of guidelines and methodologies for agency-wide use that determine the potential risk from exposure to specific pollutants. Targeted areas for assessment include exposure and carcinogenic, reproductive and other chronic effects.

The Office of Pesticides and Toxic Substances in cooperation with the Organization for Economic Cooperation and Development is developing ranking systems to prioritize chemicals so that those with the greatest need for control or testing are identified first.

Energy-related activities are carried out primarily through the Federal Interagency Energy/Environmental Research and Development Program which is planned and coordinated by the Environmental Protection Agency through the Office of Research and Development. Research projects supported by the program range from the analysis of health and environmental effects of energy systems to the development of environmental control systems. Major program areas are Health Effects, Ecological Effects, Atmospheric Transport and Effects, Control Technology, and Synthetic Fuels. In the most general sense, the total program relates to risk assessments for energy technologies by providing needed inputs. However, the activities that are designated energy-related risk assessments per se are limited. The integrated assessments component constitutes about 3-4% of the total Interagency Energy/Environment Budget.

About two thirds of the integrated assessment research occurs within EPA facilities and through private subcontractors. Other research is coordinated by EPA but conducted by other agencies including the Department of Energy, the Department of Agriculture, the Department of Interior, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, National Bureau of Standards, National Institute of Occupational Safety and Health, National Institute of Environmental Health Sciences, and the Tennessee Valley Authority. Most of the activities within the program relate to development of coal resources with lesser emphasis on alternative technologies.

Assessments of fossil fuel, wood burning, geothermal, waste-as-fuel, and solar technologies are carried out by the Industrial Environmental Research Laboratories at Research Triangle Park and Cincinnati. In addition, the Cincinnati lab is investigating the impact and control of indoor air pollutants such as radon, asbestos, formaldehyde and carbon monoxide.

A new EPA-funded project to conduct risk assessments of entire synthetic fuel systems was started at ORNL in April 1981. The

project will address the health and environmental impacts of direct and indirect coal liquefaction and oil from shale and will help to identify and prioritize data/research needs in synfuels-related health and environmental research.

Risk Studies at the Brookhaven National Laboratory

Brookhaven National Laboratory has been involved in health and environmental risk assessment for energy technologies since 1973. It is currently conducting an integrative analysis of various energy sources for the DOE/HERAP including conventional coal, oil and nuclear, and is also developing methods for comparative analysis of new energy technologies. Other areas of activity include health effects of photovoltaics; health aspects of conservation in urban transport; occupational health in industries supporting solar energy development; health effects of synfuels, including epidemiological support of a joint DOE-EPA-NIOSH-sponsored study of the Kosova coal gasification plant in Yugoslavia; effects of air pollution on agricultural crops; methods for designation of wilderness lands; and locational analysis of endangered species.

V. International Activities in Risk Analysis

The following is a list of organizations concerned with risk analysis. The list is not comprehensive, and the emphasis is on health aspects of risk analysis. This information was obtained primarily from materials reported on at the Department of Energy's Health and Environmental Risk Analysis Program (HERAP) Contractors' Meeting in February 1981.

International Commission on Radiological Protection (ICRP)

The ICRP publishes radiation protection recommentations for the general public and for those occupationally exposed to radiation.

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)

UNSCEAR provides in-depth critical reviews of the sources, pathways, and biological effects of ionizing radiations, and provides an up-to-date survey of the risks to health of radiation. In its latest report (1977), radiation sources in the nuclear fuel cycle are reviewed in detail; the 1977 UNSCEAR Report serves as a useful resource for the assessment of radiation hazard to health, occupational and public, from the nuclear fuel cycle.

International Atomic Energy Agency (IAEA)

The IAEA has a strong interest in the technical base from which to assess health and environmental consequences of all aspects of the nuclear fuel cycle. IAEA cooperates with other agencies on nuclear assessments — for example, with the World Health Organization (WHO) Regional Office for Europe and the United Nations Environment Program (UNEP) Nuclear Fuel Cycle Panel.

World Health Organization (WHO)

The WHO's Division of Environmental Health is studying pollutants in general, some of which obviously come from energy sources. A new small-scale study is underway on comparative effects of low levels of environmental pollutants from energy sources.

North Atlantic Treaty Organization (NATO)

The NATO Committee on the Challenges of Modern Society (CCMS) has produced air quality criteria documents and had several energy-environment-related projects, e.g., use of a systems approach for establishing air pollution control programs in NATO states.

United Nations Environment Program (UNEP)

UNEP has begun a reiterative program of reviewing the health and environmental impacts of individual fuel cycles with the assistance and advice of international panels of experts invited by UNEP for this purpose.

In addition, UNEP co-sponsored with Reijer Institute, Stockholm, and USSR Commission for UNEP, an International Workshop on Environmental Implications and Strategies for Expanded Coal Utilization. An excellent Workshop Report is now in preparation.

Organization for Economic Cooperation and Development (OECD)

The Environmental Committee of OECD has strong general environmental expertise plus significant potential for economic analysis of various impacts that takes advantage of OECD's strong background in economics. It has expertise in sulfur issues, long-range transport, and transfrontier pollution problems.

International Institute for Applied Systems Analysis (IIASA)

Energy with emphasis on energy modelling has been a major component of the IIASA program. With support from UNEP, IIASA undertook a limited assessment of environmental consideration in energy use. This was confined to an assessment of the possible beneficial effects of energy on human health — attempts to correlate reduced infant mortality in various countries throughout the world with energy use.

European Economic Community (EEC)

The community has dealt with many energy-related environmental problems, especially air pollution from the coal and steel

industries, water pollution, and contamination by radioactive wastes. The community has strong occupational health and safety programs that include energy and some assessment of health and environmental aspects of the fuel cycles.

Numerous relevant reports and specialized seminar proceedings have been published by these organizations.

Cooperation Among International Organizations

Earlier I mentioned the International Symposium on Health Impacts of Different Sources of Energy sponsored by the World Health Organization, the United National Environmental Program, and the International Atomic Energy Agency. This meeting will be held for a week beginning the 22nd of June. On the program will be individuals interested in risk analysis and assessment from the United States, including a science advisor to Senator Howard Baker, Jr. In addition, presentations will be given by representatives of the following countries: Canada; United Kingdom; Federal Republic of Germany; India; Poland; France; The Netherlands; Yugoslavia; Italy; Denmark; Finland; Austria; and U.S.S.R. One paper is a joint IAEA/IIASA risk assessment project for Japan. Forty one countries, including the Peoples Republic of China, will send representatives. Five international organizations, not including the three sponsors, will be represented.

It is obvious that international boundaries have little meaning for materials produced and released by man. Two cases in point are the atmospheric CO_2 and acid deposition. I think it is quite obvious that more cooperative risk studies among nations will need to be done in the 1980's.

For example, the World Meteorological Organization (WMO) recently issued an appeal for an urgent worldwide study to seek ways of controlling the impact of increasing carbon dioxide upon climate and total environment. The appeal followed a meeting of experts from WMO, the United Nations Environment Program, and the International Council of Scientific Unions. The group concluded:

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"A major international interdisciplinary research effort is necessary to develop a set of impact scenarios based upon extended sets of data not now available so as to deal successfully with uncertainty and to prepare a management plan of action adequate to cope with the likely impacts. It is essential that the research proposed here be undertaken as a matter of urgency."

We are witnessing more collaborative efforts on the international scientific level in the field of risk assessment. I have been working with a group of experts from six other nations (France, Denmark, Italy, The Netherlands, Spain, United Kingdom, and the United States) on a report entitled "The Environmental and Biological Behavior of Plutonium and Some Other Transuranium Elements," for the Organization for Economic Cooperation and Development (OECD). This particular report develops health risk coefficients for man. It is important to have input to such efforts by individuals from different countries. In this way one can attempt to integrate the various philosophies and experiences. Believe me, such studies are extensively reviewed since many countries are involved.

VI. Need for Further Developments in Risk Analysis

As the integrating component of comprehensive health and environmental studies, risk analysis also integrates all the uncertainties associated with determining exposures and hazards. Thus risk analysis will advance in general as basic knowledge accumulates. However, progress may be served if basic research were conducted within the framework of comprehensive risk analysis methods. The major role of risk analysis at present is to identify and prioritize data/research needs within a consistent and comprehensive framework. This role is of major importance but has not been utilized enough or consistently. In order to fulfill this role in a credible manner, risk analysis methods development and applications should be conducted by teams of scientists from different disciplines.

Full time support for such teams is a major present need. Multidisciplinary approaches are given much lip service and are employed in a few cases to conduct research in certain areas. But stable base support in the risk analysis context is yet to be realized. There is no commonly accepted methodology for comparison of energy technologies or other activities on a common scale. Acceptable risk has not been defined. Relative risk approaches are fraught with large uncertainties and attendant biases. We do believe, however, that progress can be made toward a clear understanding and application of risk analysis methods. Risk analysis must be established as the integrating component of research and development activities and the major activity that will interpret and translate results into comprehensible guidance for policy makers.

It is not easy to determine what national needs are in terms of risk analysis, because no one single body directs and funds this research. However, we can gain some idea from a series of questions (slightly altered here) that were posed by the Technology and Assessment Group of the National Science Foundation:

(1) How do we determine how safe is safe enough?

(2) How good are the data on which we depend for estimates of risk?

(3) How are estimates of risk translated into decision-making?

(4) How should we deal with uncertainty?

(5) What should institutions do when confronted with risk uncertainty?

(6) How do we perceive risk?

(7) Do individual perceptions of risk add up to a total view of society, i.e., does the whole equal the sum of the parts?

(8) Are some risks unacceptable, regardless of the accompanying benefits?

Another indication of possible national needs was given in the bill introduced by Congressman Ritter of Pennsylvania in the 97th Congress (H.R. 3441). This bill, designed to be cited as the "Risk Analysis Research and Development Act of 1981," is in my opinion, an important and necessary piece of legislation.

The broad statements made in both the National Science Foundation document and Congressman Ritter's bill suggest the need for a strong scientific basis for risk analysis. Some of that foundation has already been laid, but there is considerable work to be done. In particular, there is need to (a) develop the basic theory and methods; (b) support the experimental determination of risk-related data; (c) study risk perception and decision analysis; and, most important of all, (d) do the actual risk assessments.

Without the methodology, no overall risk assessment can be constructed. It is clear that improving the methodology will require advances in mathematical techniques.

The data are also a key component of the final risk assessment. In some cases much of the data are either only vaguely known or in dispute, so there is considerable room for improvement.

While the many ways in which risk can be analyzed do not lead themselves to a single unified approach as yet, it should be remembered that the study of radiation has greatly improved our understanding of risk.

VII. Summary

The following material is taken from a paper I presented at the Symposium on Health Risk Analysis in October 1980. I think it is appropriate to these hearings.

"The citizens of this country are bombarded every day with news about hazardous and toxic materials in their homes, their work places, the food they eat, the air they breathe, the water they drink, the chemicals they may encounter from various sources, the dyes that color their hair and foods, and even the materials their ch !dren sleep in. How will the general taxpaying public respond to this explosion of information concerning transformation, promoting agents, metabolic degradation products, carcinogens, teratogens, mutagens, and cocarcinogens? Many individuals will be convinced that the situation is severe but others may become saturated and selectively tune out news on the toxic materials of the day or month. A few might appreciate that knowledge is being accumulated about how materials, either alone or in various combinations, might ultimately affect them. (I say ultimately because years, perhaps even decades, may pass between exposure to a given material and the subsequent effect on man.) Many precious resources, including time and money, must be allocated to the task of deciding what materials are hazardous or toxic and analyzing their impact on human health.

"We should not underestimate the size of this task. It is a huge undertaking to test product after product even if only one test or several relatively simple tests are used, once we can all agree upon the test or tests that should be used. Then we must consider associated problems. How do we develop dosimetric schemes to allow us to relate

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exposure to effect as has been done in the field of ionizing radiation? Should we develop dosimetric schemes and models, or should we be content with learning relationships between exposure and effect? Should more effort be placed on the understanding of underlying principles and mechanisms? How can data obtained from one or more species be extrapolated to man? How do we commit our resources on a national basis, considering the large number of chemical compounds of real or potential concern? And, of course, to what level of risk should society be protected from a given material for a given level of benefit?

"It is obvious that there is a high level of interest, both nationally and internationally, in the subject of health risk analysis. I believe it is most important to discuss comparative risks and to place risks in proper perspective, especially when one is dealing with the translation of information from the scientific and technical domain to that of the general public."

Of course, Health Risk analysis is only an integral, but very important, part of Risk Analysis. We must get on with the job of understanding as best we can the risks associated with energy development and other activities. I believe Risk Analysis is the tool that will allow us to make the best decision as to what paths to follow.

I would like to include for the hearing record a copy of a paper entitled, "Risks in Perspective: Natural, Occupational, and de Minimis," that I presented to the 68th National Safety Congress and Exposition last October in Chicago.

I thank you.

Appendix 1

SOCIETY FOR RISK ANALYSIS
STEERING GROUP

C. S. Aaron
Ilse-Dore Adler
Elizabeth Anderson
Donald Barns
Charles Brown
Kenneth P. Cantor
Joseph Coleman
Vincent T. Covello
Fredrick J. de Serres
W. Gary Flamm
George F. Flanagan
Gio B. Gori
Peter G. Groer
Richard Hill
Alexander Hollaender
Chester R. Richmond
V. R. R. Uppuluri
William E. Vesely

Mr. FUQUA. Thank you very much, Dr. Richmond. I want to ask all of you who would like to comment on a particular question. It goes along the comments Dr. Ramsay was making, if I understand him correctly. Is risk assessment more of a science or is it an art?

For instance, suppose you had a group of experts in risk assessment examine the same problems, such as the accident risk associated with a particular nuclear powerplant, or, as you mentioned, Dr. Richmond, the risks due to emissions from a synthetic fuels plant. How similar do you think their conclusions might be? Maybe all of you would like to comment on it.

Dr. RICHMOND. I will try first, if I may. It is a very key question. I think we have to realize that risk analysis is a new—relatively new—like a decade or less old. It is an evolving branch, if you will, of science, practiced primarily now by scientists; and this includes the so-called soft sciences, the legal profession, and others, economists, et cetera. If you step back about 5 years ago, when people first tried to stimulate interest in the comparative risks of energy-generated systems, I think you would probably find that the most obvious finding was very broad ranges in the estimates, be it morality or morbidity.

There were other contributions that added to the confusion, I think that is the proper word, because people would tend to look at one link in the energy cycle, perhaps the energy generating plant itself, and they wouldn't worry about disposal, or they would concentrate on the mining and not enough on generation.

In time I think we have seen that more and more studies are giving more convergence as different people do comparative risk assessments. Some component of the uncertainty will remain and can only be answered in the future; but the short answer to your question is, I think, as people use different—not the same but different—methodologies, we are seeing more convergences in the kinds of answers we get as you look at various energy-producing technologies. Still a long way to go.

Mr. FUQUA. Dr. Ramsay?

Dr. RAMSAY. My impression is that although there is some convergence, it is not adequate yet. I certainly agree with the general tenor of what Dr. Richmond is saying. I guess what I would like to emphasize in this, which is sort of to the point, is that we have to be careful about a tyranny of numbers, I guess.

And that is, as both of my colleagues have also mentioned, there are many effects for which it is very difficult to put a number on. But those effects, for instance, the carbon dioxide catastrophe, may be more important than the ones that we can deal with numerically.

I think everybody—certainly everybody seriously into risk analysis, fails to realize this, but I think this is something one has to be very careful of in dealing with legislation, and in dealing with the public, that we are able to look at the whole picture and keep in mind that effects that we are not able to put numbers on, may be very important. And as Dr. Richmond has emphasized, that even on the ones we can put numbers on, there may be a great spread in what we know about them.

Mr. FUQUA. Dr. Lave?

Dr. LAVE. Risk assessment is a science in the following sense: If someone makes a calculation, other people attempt to replicate and evaluate that calculation.

It is also a science, although not the kind we learned about in high school textbooks, in the sense that if you present scientists with a problem, they will use a number of different approaches to arrive at somewhat different answers. For example, 100 years ago if you asked somebody there were a number of different approaches to measuring the speed of light; they lead to somewhat different answers, but all fell within a narrow range. That range is much larger for risk assessment now than it was for the speed of light then, but we are converging.

The point Bill Ramsay just made is the one to be stressed: there will always be important aspects of the problem that are unquantifiable. Unfortunately, there is a tendency to pay more attention to numbers than to the other aspects, even when you believe the other aspects are more important. We always have to guard against that.

Risk assessment is a science in the sense that what can be quantified can be examined and eventually there will be estimates that are generally accepted. It is art in the sense that the conclusions you draw from it often will not be shared by other analysts.

Dr. RAMSAY. I think we have to say that the mathematical formulas are very useful in organizing our ways of thinking about it. I have to say that, for instance, my view, which is shared by very few of my colleagues, is that the greatest danger from nuclear power is that some political person, not in the United States, I would hasten to add, will explode a nuclear weapon over my head.

I think that this is a question that is very difficult to quantify, but I think it would be very foolish of us to ignore that as a possible concomitant of nuclear power.

Mr. FUQUA. What do you think are the proper uses of risk assessment and what are the limitations of the techniques? I guess what I am trying to say is what kinds of questions can risk assessment answer, and what kinds of questions are beyond the capability of the technique?

Dr. RAMSAY. I was reminded in this question about the OSHA regulations, and this doesn't have to do with energy, but that is an example of something where you are talking about one effect, which is circumscribed. Now, there are lots of unknowns about it, but that's something where risk analysis could really, I think, do something.

When you get into these questions of coal versus nuclear power, where you have about 10 different effective health effects, eight different important environmental effects, some are catastrophic, and some are noncatastrophic, I think risk analysis in its present form, although very useful, as I say, as a method of organizing our thinking, is much less useful as a direct basis for legislative decisions.

Dr. RICHMOND. I will try to answer that also. I didn't cover all of the points in my testimony, but I might give you several examples of specific risk assessments that are underway at the Oak Ridge National Laboratory now, just to pick a few from my list. One is the health and safety impacts of Eastern oil shale development.

Industry and others are now recognizing that in addition to oil shale in the West, there is oil shale in the East.

Moreover, in the East, obviously, there are other metals and materials in the Eastern shales. As people are now starting to look at extraction procedures, it is important early on to start thinking and looking quantitatively, as best as we can, at the potential health and safety impacts of exploiting Eastern oil shale.

Another one, for example, is the health and safety issues associated with combustion of toxic substances in high-temperature incinerators. There was a question from one of the members of the committee earlier about the closing down of systems used to get rid of garbage.

As I said earlier, everything has to go somewhere. So we are now even beginning to wonder about exposure to individuals who might be working around incinerator systems in terms of potential releases. So the point is that risk analyses can be applied specifically to individual portions of an entire energy cycle.

Another example might be to look at the potential impact of energy transmission lines on flora and local communities, so I think there are many examples that we are using in comparative risk assessments, in addition to the large components of risk analysis where often you run into the the more far-off uncertainties that we have discussed earlier.

Mr. FUQUA. Dr. Lave?

Dr. LAVE. Let me try that one, too. Risk assessment is most useful when you have the most knowledge. A risk assessment of a brand new chemical we knew nothing about would generate a range all of the way from minus infinity to plus infinity; it could be the most toxic material we have ever seen or completely benign.

If we gave our best risk assessment of this unknown chemical we would have to say it could be anywhere within that range. That is not very useful. That is taking up time and contributing nothing. The more we know of an activity or circumstance, the better or more helpful that risk assessment is going to be.

We know an awful lot about the generating phase of nuclear power. As long as we are talking about current, not future, technologies, there is fairly general agreement about the qualitative and quantitative visits. That doesn't mean we have narrowed the uncertainties down to zero, but risk assessment is very helpful. As soon as we move out of the generating phase and focus on waste disposal, there is less agreement. We know relatively little about waste disposal since we don't have any current operations. We can characterize hazards and expected cases that could come out of it.

There are a couple of rules of thumb I use for when risk assessment is useful. The first is, how much do we know? Do we know enough so we can begin to quantify? The second is, how close is future technology likely to be to current technology?

The table that I presented is based on the experience with current systems, systems that are currently in operation. The future could hold huge breakthroughs to make some system much safer than it has been in the past, and that might reverse the conclusions.

But we have to make judgments now on the basis of technology we know about now. We can't wait for the indefinite future.

A third criteria would be: How many of the elements in the risk assement are intangible, compared to risks that can be quantified? For example, do effect like future carbon dioxide concentrations in the atmosphere loom large, or is there no disaster potential? The more important the intangibles, the less risk assessment will be able to contribute.

Mr. FUQUA. Thank you. Mrs. Bouquard?

Mrs. BOUQUARD. Thank you. I want to commend all three of you for your fine testimony. Dr. Lave, I would like to refer to page 7 in your testimony, which said:

> More recent investigations have examined the risks associated with various solar technologies as well as of burning wood for home heating (Morris, 1981; Rowe and Groncki, 1980). Contrary to popular belief that these energy sources are benign, they find that the health risks of photovoltaic technology and of wood burning are higher than those for coal. This is not an area where one's casual impressions can be relied upon.

Could you elaborate a little more on the findings of the Brookhaven National Laboratory study on risks associated with various solar technologies, and how these risks compare to the present conventional energy sources?

Dr. LAVE. The specific study on wood is one in progress now by Samuel Morris. Basically, lumbering is one of the most dangerous industries in the country per man-hour. It is on a par with coal mining. Wood to be used in the home has to be gathered somehow. Somebody is going to have to chop down trees, transport them, and cut them up. These are very dangerous activities per man-hour. Unlike coal or nuclear, you get very little energy per man-hour. Consequently, there is a lot of danger per Btu of energy.

The second phase is burning the wood. There is a significant increase in the number of fires in the home that come from having wood around, either because the sparks that come out of the top of the stack or the fireplaces that are left unattended. There are marked increases in the number of fires in the home caused by burning wood.

And finally, the fumes from burning wood contain a number of carcinogens such as benzopyrene. More importantly, the smoke is emitted in your house or at the roof. If you go out on a winter day when your neighbor is burning wood, you can smell those fumes. They may smell like the country, but not the most pleasant parts. If many people in a large city were burning wood, you would have a public health problem from the smoke. I hasten to say that these are all preliminary observations, made by Sam Morris in his paper. I want to emphasize that the table represents current technologies. If those technologies change, for example, if there is tremendous progress made in photovoltaics, the results would be different. But then there may be tremendous changes in all of the technologies represented in the table.

When I did my work the nuclear engineers talked about how wonderful nuclear power would be in the future, the coal people told me how they would have completely automated mines and how the burning of coal would not even give a single whiff of any pollutant.

I hope so, I genuinely hope so for all of us. But in the meantime, we have to make decisions. The table shows that the solar technologies are currently inefficient, relative to coal and nuclear. Thus,

there is a great deal more cost and a great deal more man-hours going into them.

Most of these activities are safer per man-hour than mining coal. Yet there are so many more man-hours required to produce 1 million Btu from wood or from solar that they turn out in the end to have more disabilities and more fatalities, per unit of energy output, than does coal or nuclear.

Mrs. BOUQUARD. Thank you very much.

There is more than one factor considered in making all of these determinations so they can't relate back to one specific area?

Dr. LAVE. Right.

Mrs. BOUQUARD. Thank you very much. I appreciate that.

Dr. Ramsay, do economic penalties and additional costs incurred by powerplants to meet environmental standards carry risks that could be compared to the environmental risks, both by not having completely complied with such standards and using the money in other ways? Can you mix these factors as well?

Dr. RAMSAY. You are asking if we lack the power, could this pose a risk. Yes, as I was just remarking to Mr. Blanchard at the recess, for instance, if we considered that nuclear power were the only way to generate electricity, we would be thinking quite different thoughts about nuclear risks, and I think the public would say gee, we really want electricity. You probably would not have to make very complex arguments about the economy because people would say that is something that I really want and I will put up with the nuclear risks. I think the big caution about nuclear power is that it's not the only way. In a nation where it appears that nuclear power is the only way they are going to get power they tend to feel something different. There is a tendency for them to feel something differently.

Mrs. BOUQUARD. It costs them to comply with environmental standards. Can you compare these costs to the environmental costs if you don't implement these standards using the money another way?

Dr. RAMSAY. In the old days when we worried about thermal effluents from powerplants you could say well, we will let out the hot water or warm water and let the fish take their chances, or we can put in these complicated cooling systems at a great deal of expense. It was never clear to me, when I worked on these questions at the Atomic Energy Commission, that there was any way of answering this question if really there is no marketplace for it. The fish are out there, fishermen will get very unhappy. If the case was something like the striped bass in the Potomac, where they might be impacted by a powerplant in the Potomac, it was just a question of how could you tell if it's worthwhile putting in a cooling tower. Well, you know when you come down to it, about the only way you could do it was to turn the question on its head and say, well if the Congress decided that those fish were important enough that we are going to put in a cooling tower. That must be how important the fish are because I don't think there is any other way of telling how important those fish are.

Mrs. BOUQUARD. Thank you.

The CHAIRMAN. Mr. Dunn?

Mr. DUNN. In your prepared testimony at the bottom of the first page you say:

> In the case of the auto, over 10 years ago Congress successfully regulated safety emissions and fuel economy, and may yet get around to regulating the other important aspects such as price and styling.

Are you seriously suggesting that Congress design cars?

Dr. LAVE. That was a jab more than a pat on the head. That's that by——

Mr. DUNN. Thank God, sir, thank God. [Laughter.]

Dr. LAVE. By the way, I don't mean to crack the distinguished Congressman, but you said "successfully," I didn't say that. I said "successively."

Mr. DUNN. You are right, I misread that, too.

Dr. LAVE. It's just that if the regulation goes that far, then there is very little left for the private sector to decide.

Mr. DUNN. You had me worried.

Dr. Richmond, down there in Oak Ridge, I wonder if you have done any risk analysis on your potential neighbor, the breeder reactor?

Dr. RICHMOND. There have been many studies, generic studies, about the potential health environmental impact of the breeder reactor using a reference design. As you know there are no breeder reactors producing electricity in this country at the present on a large scale. There are——

Mr. DUNN. We are aware of that.

Dr. RICHMOND. Painfully aware. I am not sure the audience is. The point is that there have been generic studies that have been designed to try to look at and assess the number of cases—injuries and deaths—that might accrue from, for example, 1,000 megawatt [or gigawatt] breeder reactor. Problems that we all discussed earlier were very apparent in some of those. For example, not enough information may have been known in terms of the fuel reprocessing requirements, the potential——

Mr. DUNN. You have the example of French plants to work from, don't you?

Dr. RICHMOND. Yes; there obviously is some fuel reprocessing in this country related to the weapons establishment. The point I was trying to make is some of the estimates in some parts of the cycle for the breeder. I can't give you any details on this.[1]

Dr. RAMSAY. I would say just on general principles there was some feeling that the breeder is probably safer than the light water reactor just because it's a nonpressurized system. I think a lot of people are having second thoughts about the use of having gone into light water reactors 20 or 30 years ago. That's—of course, if you don't count the fact that the breeder makes material that's awfully good for making nuclear weapons.

Dr. RICHMOND. If I might continue, please, an important point was made that I don't think we should let escape us—that was made a few minutes ago by Dr. Lave—that's technology changes with time. Risk analyses and assessments should be iterative; that is, you might conduct one this year on a given technology and 2 or 3 years down the road you probably will need to be reassessing and

[1] ERDA-1535, "Final Environmental Statement, LMFBR Program," vols. 1-3, is an example of a risk analysis for the breeder reactor technology.

reanalyzing because there might be drastic changes in that technology. So I think we shouldn't get the idea that once you do a risk analysis on a system it's done forever. It's an iterative system that matures along with the technology that might be developed.

Mr. DUNN. I wonder if Dr. Ramsay didn't hit the nail on the head in talking about either nuclear power or coal. That is, we really aren't there yet other than to use risk analysis as a thought process. In those particular areas, to try to defend it when using it in energy technology, it's not quite there yet; is that correct?

Dr. RAMSAY. That would be a correct reading.

Mr. DUNN. Would all three of you agree with that?

Dr. LAVE. Yes, sir.

Mr. DUNN. I thank you very much.

Mr. SCHEUER. Thank you. I want to commend the witnesses as well as my colleagues for their outstandingly helpful testimony.

Dr. Lave mentioned that one of the criteria by which you evaluate usefulness of the risk benefit analysis is the amount of data you have. I have also been troubled when we use risk benefit analysis on nuclear energy by the fact that we have never had a serious nuclear accident either in this country or anywhere else in the world.

The data we have gotten from the Three Mile Island incident that Dr. Ramsay mentioned proves to me the opposite of what it seemed to prove to you, not that it was risky, but that the physical technology was so good and there were so many layers of safety and fallback positions, and so many duplicative safety nets that with the most incredible succession of gross human error, where they ignored the signals, ignored the dials, and ignored everything that the system was trying to tell the operators, still there wasn't a dangerous nuclear accident. And when you have never had a nuclear accident—and I suppose mathematically that you could come up with a statistic probability that you are going to have 200,000 deaths once every 5,000 years or every 1,000 years, or every 100 years. Does that have meaning relative to predicting that you are going to have 200 deaths a year, extrapolated from real life experience, in mining coal? It seems to me that if you are to assess risk-benefit, you should also factor into it Dr. Lave's hope and reasonable expectation that our safety devices will improve—they certainly wouldn't deteriorate.

We have been fiddling around with nuclear power all over the world, at least in the developed world, without any kind of a serious nuclear accident that I know of. Now can you apply a cost benefit to it and how can you really compare it with other forms of energy production without looking at real world experience in all of the European countries, Australia, New Zealand, Japan, Canada, and say this is by far the most risk-free form of producing energy.

I don't mean to be a Pollyanna, but it seems to me if you look objectively at nuclear power it's by far the cleanest and safest of any form of any energy production that the mind of man has ever been able to devise. And I care about safety and I was the author of legislation prohibiting the transportation of nuclear waste by air because the Nuclear Regulatory Commission had not up to that time developed a safe container that would withstand the impact and the heat and the crash of an airplane. I did that 7 or 8 years

ago. So I am concerned about safety. But how can you use risk-benefit analysis and come up with—if you factor in relative experience—any conclusion other than that, virtually beyond question, nuclear is the safest and cleanest form of energy? I would like to ask that of all of you. If I am overlooking something, please tell me, because I am concerned about the public, I am concerned about consumers, I am concerned about nuclear devastation in war as well as in peace. But it seems to me the real life experiences are quite clear and virtually irreputable.

Tell me if I am wrong.

Dr. LAVE. I think the point you make is an excellent one. And in part it's a testimony to how far we have gotten with general risks in society. We regulate risks, and in almost all cases what we are regulating are theoretical risks. There are no bodies lying in the street; rather, on the basis of our best scientific calculations, there would be some harm done.

You mentioned the *Benzene* case, last year. The Supreme Court decided those theoretical risks, were not significant. The risks for nuclear power are almost entirely theoretical. That doesn't mean they are not real. It means, though, that they are calculations. When you are regulating theoretical risks, every time you get a year's worth of experience, you know a lot more than you knew before.

It's almost beyond my imagination that we would have no accidents that would result in human death if we had a very large system of reactors in this country that ran for a century. Human beings don't work that way. Various scientists have been engaged in an elaborate exercise to imagine those risks. Conservative assumptions are made, which generate controversy.

The point is we are always dealing with theoretical risks when we compare one energy form with another. It is important to be even handed in applying comparable assumptions to each technology.

Mr. SCHEUER. You are saying as a matter of statistical probability, if we had hundreds more of nuclear plants in this country and looked forward to operating them for a century, you cannot conceive that there wouldn't be some major nuclear accidents?

Dr. LAVE. I beg your pardon. I said there wouldn't be an accident whose direct result was a fatality.

Mr. SCHEUER. I don't think we are talking about accidents in the order of magnitude of one or two or three. When you think of nuclear power you are not thinking in terms of a steady flow of 200 accidents a year or so that we have with coal mining, you are thinking of the urban cataclysm. It seems to me that if you can project some improvement in technology, and if you can look at the extraordinary way to which the safety system at Three Mile Island counterbalanced the most egregious series of human errors, and worked, you could pretty well prognosticate a virtually risk-free operation even for a century, with some kind of minimum standards for the humans that run these plants. I don't want to belabor the matter but here you have two reasonably intelligent individuals taking exactly the opposite lesson from the same incident. I just wonder—if I am wrong I would like you to tell me.

Dr. RAMSAY. It's not a question of right—I knew your name was famous because I was at the Nuclear Regulatory Commission when your legislation was put through, which was appreciated in some parts.

Mr. SCHEUER. It was not appreciated at all, Dr. Ramsay, because, with no offense meant to you, the Nuclear Regulatory Commission was egregiously dishonest in the way they represented my legislation on the Senate side when it was being considered.

Dr. RAMSAY. I am saying there were some of us——

Mr. SCHEUER. As long as I have gone that far, let me just elaborate by saying that my legislation mandated the production of a safe container for nuclear material. On the Senate side, they fought it by saying that there is no such thing as absolute safety which is what Congressman Scheuer's legislation provided. There was no such word as "absolute" or "finite". It simply said a "safe container". Well, safe is something that would be reasonably safe. Then they went on to say we are just on the verge of developing one and we will have it in another few weeks or days so why legislate?

The fact is that 6 or 7 years have gone by and that legislation is still on the books. They have not, to this day, certified to Congress that they have developed a safe container.

But to prove that human beings are fallible, I was trying to improve the safety of transportation of nuclear waste material. If they ever had any processes of developing a safe container they gave it up and started transporting all of this stuff by truck and they are doing it to this day.

So if I had put into a computer what was going to happen, the scenario that would unfold if I was successful, I could have easily figured the danger would be enormously magnified by the success of my legislation so I don't take a great deal of credit.

I would like to yield back to you.

Dr. RAMSAY. I believe with Lester that we have to do these things theoretically. As you know, I think one of the biggest things that happened is that you can read Three Mile Island the way you read it or the way I read it. I think that what happened was that both the Loomis Report and Three Mile Island both cast great doubt on the report which had been the thing that we were relying on as assessing the theoretical risk. It is certainly true that every year that goes by and there is not a serious accident is more statistical evidence that nuclear power is all right.

I think even nuclear advocates would say that we don't have enough experience on nuclear power that given the possible magnitude of a large accident, that we can say that the probability every year is small enough that we don't have to worry about it.

I think that——

Mr. SCHEUER. Worrying about it is the greatest safety net of all. So long as we continue to worry, we may have a chance of getting away without a serious nuclear accident. God help us if we ever stop worrying.

Dr. RAMSAY. Dr. Lave also said they expected a few people to be killed. Dr. Weinberg at Oak Ridge has said the same thing. It is something in a very unstable system with dangerous elements in it. It is something where you might expect some deaths. On the other

hand, that number of deaths might be smaller than the amount you expect from say natural gas explosions, if gas were replacing that nuclear electricity. That we don't know.

If you talk just about nuclear, I don't think we have enough exprience.

Dr. RICHMOND. In trying to answer part of the question, simply put it in context on Three Mile Island. Actually there were estimates of the harm from accidents involving "small releases", noncatastrophic. The paper I mentioned earlier by Sir Edward Pochin from the United Kingdom last year [1] is on biological risks involved in power production. He actually refers to this, and as Dr. Lave said, the problem is often approached now by doing calculations of the failure rate of individual components of the system.

It turned out the WASH 1400 study projected the value of about three units, three man sieverts—these are international radiation units—per gigawatt—(TAIS being a large, modern powerplant, 1,000 megawatt). If you look at the amount of electricity that was generated 2 years ago when the Three Mile Island accident occurred, it turns out that the population dose to the several million people living within a 50-mile radius of Three Mile Island was such that there was 1.5 man sieverts per gigawatt of electricity in the United States.

So there was an estimate made for that release and it looks like it is within a factor of two of what happened.

Mr. SCHEUER. I have to leave in 2 minutes to catch this vote. We will recess for 10 minutes and I hope afterward we can get all of you to respond to the Supreme Court decision.

[Recess.]

Mr. FUQUA. The hearing will resume and recognize Mrs. Schneider.

Mrs. SCHNEIDER. Thank you, Mr. Chairman, and thanks to all of you for your patience in our processes of running over to do our voting. I have a couple of questions touching on some of the other things that we were discussing earlier. How do you simulate the real risks associated with a particular event or technology when a number of the factors that we have been talking about earlier are strictly theoretical and can't really be quantified? How are we going to be able to determine public policy when we are dealing, at times with qualitative rather than quantitative information?

Dr. RAMSAY. I think Dr. Lave emphasized that the short answer is you can't. If you don't know something about a technology, maybe you don't know enough to do anything about it. As you know for nuclear power where we didn't have the information, the tack taken was the same as people did for missiles when they really didn't know much about failure rates for missiles, but they could take all of the individual parts of the missile and figure the individual failure rates and put them all together. Even with the problems in the Rasmussen Report which Dr. Richmond can probably explain to you better than I, I think that method remains certainly the only way of approaching these things.

Now as you are talking about having to rely on qualitative decisions, I suppose you are much more of an expert at that than I. It seems to me that we are stuck, in contending with these various

[1] "Biological Risk Involved in Power Production," Physics in Technology, 11:93-8, 1980.

technologies, with relying on qualitative decisions and I see no way out of it, so that one cannot stand and wait for even adequate information as Dr. Lave has testified. One must go ahead with the best combination of qualitative and quantitative information available.

Mrs. SCHNEIDER. How would you recommend that we integrate the risks to individuals and the risks to society as a whole, in coming up with one risk estimate? For example, we can consider a nuclear powerplant and we might say, well, it is all right if the workers are exposed to this amount of low level radiation and maybe we will allow them to be exposed to a little more low level radiation than might be acceptable for those who are neighbors, for example, of the nuclear powerplant.

Dr. RAMSAY. The way economists like to think about these things is in terms of compensation. Theoretically the worker in the nuclear powerplant would get an extra premium, just in the same way that the window washers or steeplejacks presumably get paid a little bit extra for the danger.

In the same way, ideally, the people living close to a nuclear powerplant should be compensated in some way for the extra danger. Now in the actual world, that does not work that way, but as far as the premium paid for these situations, I think that is the way this kind of society had dealt with these dangers in the past.

I think what we are seeing now is the fact that people are surprised. It is like the problem with the cotton dust, you know you don't go down in the coal mine and say, "gee, this is a dangerous job. I realize it", because everybody knows that. Everybody knows coal mining is dangerous. There is a thing that may not be fair, you may not have a free job choice. That aspect is always there. Other than that, if people have free job choices, most neoclassical economists would be very happy saying, "Oh, well, you get paid more for a more dangerous job. That is the way it is."

I think what is worrying in the situation with cotton as with many things, is that a danger is discovered all of a sudden. People didn't know there was this danger in cotton mills. Then what do you do about it? Do you do it by regulation, which I think is the tendency because the wage policy in the industry is not set up to pay these people for the extra danger.

Mrs. SCHNEIDER. Thank you. Did either of you other gentlemen have any other comments?

Dr. LAVE. Could I respond to both of them rather quickly? We have known about brown lung disease since the 1920's. We are living in a high-technology society; in such a society, we need a vast amount of analysis and judgment to estimate these risks and make intelligent decisions.

Someone might object that no one could be confident about any individual estimate. How do we know that we are not ignoring the major factors? I don't think we can be confident. We can only make our best judgment. Society then has a decide whether it wants to have high-technology activities. Wouldn't it be better to back off? This is a question to be seriously asked. Given that there are these high-technology activities, it makes no sense to ignore these risk calculations.

No society should tolerate risks to individuals which amount to suicide. Coal miners have a risk of accidental death of 1/1000 per year; that is close to unacceptable. Aside from that, Dr. Ramsay's answer is right. Where we have jobs or geographical locations with greater risk, then probably the better mechanism is to compensate individuals to achieve equity.

For example, we need oil, there are divers working at depths of 1,000 feet. That is a terribly, dangerous activity, but we want that oil. Society compensates those people handsomely for the risks that they take. I prefer to pay rather than do without the oil and they prefer the money.

Mrs. SCHNEIDER. Very well, thank you.

Dr. RAMSAY. I stand corrected on the discovery of brown lung. Perhaps the current interest in it comes more from a change in emphasis in society to which Dr. Lave referred, such as wondering whether we need one technology or the other. This is possible, or when the general level of health improves, then people become much more aware of these things and we discover that we may have to recast our regulations to reveal the fact that since a person expects his lifespan is going to be longer, he does not want to get this strange disease from industry.

He may be more intolerant.

Mr. RICHMOND. Let me, if I may, add one more view to this. The reward system obviously works. The people who are developing offshore oil down in the gulf are well rewarded for their employment but it is one of the largest causes of occupational death, now, in the oil industry, and in the State of Louisiana. I have some information on this in the paper I put together last year on occupational health risks and de minimus risks which might be worth adding to the record in this hearing.[1] But the de minimus risk concept I think is very important. If you follow the reward system, to what level do you reward people for risk and where do you stop?

So I think in addition to considering some kind of reward, monetary or others, one must keep in front of him this question of de minimus risk. Is there a level below which we will not impose regulatory action or reward system and so forth? But perhaps more importantly, if you have a de minimus value that can be agreed upon, societally, that will help direct activities, research, legislative and others, to areas where the risk and the uncertainties may be much larger where we should be directing attention.

Mrs. SCHNEIDER. I think that what we should do is add another dimension into that also and you mentioned the term death, as part of the overall equation. Insofar as public policy is concerned, I don't think that we should use death as a definite parameter but rather we should look at the quality of life. I think that if this is public policy, then we will be more in a position to say, well, wait a minute, let's look at this a little more closely because I personally can admit that there are many people who would rather die than have to go around in a wheelchair or many people who would rather be dead than to not be able to see or speak or whatever. So I think that oftentimes it is said, well, no one was ever killed in this particular occupation. That is not the question. Was the remainder of their life miserable and if they had had this information prior to

[1] See appendix, p. 126.

taking this job, might they then have made an effort to obtain a different kind of job or might they have made an effort to place controls on that particular type of work?

Dr. RICHMOND. If I may respond, that is a very good question. We are trying to evolve additional ways to measure detriment. Morbidity and mortality are fairly obvious but it is easy to measure death. We were talking about the uncertainties before and the fact that we are getting more refined on how we measure impacts, so I think the logical starting place was to look at mortality.

But decrease in lifespan, for example, is another end point some people are using in risk analysis studies—perhaps economic impact. There are many other potential end points. I think it is important, as we get more refined, to explore these.

Mrs. SCHNEIDER. Thank you, Mr. Chairman. I guess the only other thing I might like to put on the record is that the more we have looked into this now with the benefit of your expert information, I am more and more convinced that in providing a risk analysis of various energy technologies, that where one goes with that information is important rather than putting it on a shelf as so often happens to much research. We should go to the general public and provide them the open forum and public participation to help them become part of a decisionmaking process. I am concerned that, as you stated, Dr. Lave, there is that real possibility that, given the information, that now perhaps we are in a technological society, if we have a little bit more knowledge about the risks that we are taking, for example, just in the energy area, we may choose the least technologically advanced systems for energy production. I am of the opinion that if one has a risk analysis, plus the cost-benefit analysis, then I think we might see a different direction in our energy policy, if the public plays a role in it.

Dr. RAMSAY. Information is important. I was 15 minutes late getting here because I leaned against the wall. Leaning against the wall is usually a safe thing to do. I came away with my coat covered with yellow paint. I think it would have been fair if they had a sign up saying, "wet paint" but I felt very aggrieved because there was no sign.

So, seriously, I think that is something that Congress can play a big role in, being sure the public is informed, even if, as my colleagues agree, we do not have perfect information. The public should have the best we can get.

Mr. FUQUA. Thank you very much. I think Mr. Scheuer has some followup questions.

Mr. SCHEUER. How do you factor into the equation that the risks to health and safety on any job are quite predictable and the expense—it's also quite predictable—of avoiding or minimizing those risks, compared to risks that are unavoidable for people? In other words, if you choose to work in the cotton industry, you choose to take the risk of brown lung disease. If you work in a deep coal mine, you choose to take the risk of black lung disease. If you choose to work around one of these incinerators we talked about, you opt to take that risk. How do you compare those risks as a moral question? In your risk benefit analyses, how do you factor in things like risks that elderly people pay through no act of theirs, through no option of theirs, of all kinds of pulmonary diseases and

inflictions, that infants take from emissions from smokestacks that—where they are involuntary risk-takers and gain no benefit, economic or otherwise?

Can you make a moral distinction between those risks as we pack them into some kind of formal risk benefit decision making structure?

Dr. LAVE. I think your point is well taken.

Mr. SCHEUER. I am not trying to make a point. I am really asking a question.

I am really troubled by the moral character of that issue.

Dr. LAVE. There is a difference between known and unknown risks. For example, before around the First World War, there were a group of women who were painting radium on watch dials to illuminate them in the dark. Every time each would try the brush with her tongue to get it just right. Many of those women died of bone cancer as a result of the radium they ingested. They had no idea they were taking that risk.

Morally we ought to feel differently about them than about a high iron worker. We don't know what the public regards as being morally different about one kind of risk versus another. So far, we have tended to simplify, simply say a death is a death, whether it was due to somebody taking risks that they knew perfectly well or somebody who was taking risks that they didn't have any idea they were taking. People do distinguish between risks. If we had fuller public discussion, then the public would tell us that they regarded some risks as being much worse than others. We have tended to act as if the public didn't know enough to be brought into these discussions; that's a reprehensible position for a democracy. In the end the people will decide and we ought to believe they have enough good sense to get the best information, however uncertain it is, and to make a decision.

Dr. RAMSAY. The way the people get the control so that they make the powerplant emissions a voluntary risk rather than an involuntary risk is through you people, through Congress, and legislation. It's one of the consequences of our complicated economic life. I don't think there is any central difference between voluntary and involuntary risk that we can see. I would be more than willing to back up Dr. Lave in saying that we really need more information about how people view these risks. We have been talking to ourselves on these things, we need more experiments on that. But I think the public has discovered that one way to deal with this issue is through political pressure and that's what politics are all about and that's what it is for, that's the bottom line.

Dr. RICHMOND. I think there is a very strong component of informing the public, involving your question——

Mr. SCHEUER. Small?

Dr. RICHMOND. No, strong. Informing the public, and I think that's another responsibility of the scientific community where they have not done very well in the past. If you are involved as a worker in various occupations you are in a sense accepting that risk. You are being reimbursed for it. But the general public is the recipient of residual or perhaps involuntary risks from many activities. So we have to grapple with that question. What can the lay person do? They can read the papers and say well, someone has

just told me the risk of my dying from nitrosamines in bacon or something in scotch, it's 10 to minus 6 or 10 to the minus 8. That doesn't mean much. If you tell people that their inherent risk of death from cancer is 16 percent, and start putting these values in perspective it means a lot. It relieves anxiety, No. 1, and you can start giving the individuals a frame of reference that they can start saying, gee, now I understand what it means when someone tells me I have got a 1 in a billion or 1 in 10 billion risk. I think that's going to be more and more important and many people in the scientific community think that is not a function of the scientists to help change the perception of the public, but I personally believe it's a very important responsibility for the scientists to help convey information to the lay public so that they are better prepared to make these decisions.

Mr. SCHEUER. Of course, one of the problems there has been Government agencies themselves. An example is the Food and Drug Administration where it takes anywhere from 10 to 15 years expenditure of anywhere from $50 to $75 million to get drugs approved in this country that have been in widespread use for a decade or more overseas throughout the developed world. But there seems to be an attitude in the Food and Drug Administration that they are looking for a risk-free pharmaceutical.

And if there is even a question of—even a hypothetical question that they may be carcinogenic, for example, without any evidence that they are, they will deny life-enhancing, life-saving drugs in America which result in desperately serious suffering by thousands of people and needless deaths by other thousands of people because they are trying to figure out how many angels can dance on a head of a pi[illegible]

And if you figure out whether drugs, as I said, that are being used all over the world for serious illnesses can be approved here and other drugs like saccharin, Congress had to tell the Food and Drug Administration, get the message out, let the American people make the mistake—let the people make their own decisions and if their chances of getting cancer of the bladder, and if their lifetime predictable chances of getting cancer of the bladder goes up from 0.005 to 0.0052, that's a decision each individual ought to make and the Government should not impose on them one way or the other.

So a tremendous education——

Dr. RAMSAY. That's a situation where the public can see the benefits presumably as far as dieting or whatever. With the drugs it's a little trickier because there are substitutes for drugs and it's not difficult for the public to see how these change.

Mr. SCHEUER. I know the hour is getting late and you have all been extremely generous with your time. I mentioned——

Mr. FUQUA. I might ask, do any of you have a time problem? If you do we will certainly understand.

Dr. RAMSAY. I would like leave in 10 minutes or so.

Mr. SCHEUER. Requiring you to go through these long hours of testimony is really testimony to the remarkable quality of the knowledge and insights that you are giving us. You have to accept the blame yourselves. If this was pedestrian testimony we would have closed it down a long time ago. Let me ask you a question

about the Supreme Court decision and whether any of you would like to comment on that.

Dr. LAVE. There were two important decisions. Last year, in *Benzene* the Court said that you could not regulate unless there was "a significant risk." For carcinogens and other toxic substances, the risks are theoretical. The Court held that the estimated risk had to be significant, not simply some small positive number. This year, in cotton dust, the Court said benefit-cost analysis was not required by Congress; Congress settled the issue as to how safe workers ought to be when it wrote the legislation. The phrase in the legislation is that OSHA is to protect workers to the extent feasible and feasibility is interpreted by all parties to mean both economic and technical feasibility. Do you have the equipment? Will the industry be bankrupted? If the industry won't be bankrupted and you have the equipment, the Court said you have to remove a significant risk.

The example I might give is if the standard for benzene had been 100 parts per million, then that would have been a significant risk level. One interpretation of the current decision is that OSHA would have had to go all of the way to a level which was at the limit of either economic or technical feasibility, whichever came first. That level would almost certainly have been 1 PPM, the standard rejected by the Court since OSHA hadn't found a significant risk at 10 PPM.

If the preexisting standards for saccharin had been 100 parts per million, then the Supreme Court would have sanctioned OSHA going down to 1 part per million, since the standard was 10 parts per million, the Court would not let OSHA consider it.

Economic feasibility is a crazy test. It means if you are a worker in a marginal industry such as cotton, then you are in trouble because the industry can't afford protection. If you work for the petroleum industry, then industry profitability will allow stringent protection. You might think, tongue in cheek, of the AFL-CIO urging OPEC to raise prices so the oil industry could be more profitable and the workers could be made even safer.

By interpreting the law, the Court gave us good law and poor policy. I don't like the law, but it is the job of Congress, not the Court to direct the agencies. I don't think the Court ought to make up out of whole cloth what the regulatory agencies ought to do.

Mr. SCHEUER. Nor make up out of whole cloth what they thought Congress was telling the regulatory agencies to do.

Dr. LAVE. There was a dissenting opinion by Justice Rehnquist. He said that, if Congress had prescribed or proscribed cost-benefit analysis in the OSHA bill, there would not have been a bill for the President to sign. Rehnquist conjectures that if Congress had to settle these matters to give guidance to the agencies, then we would see a lot less legislation. What Congress has tended to do is to shy away from the very difficult issues and say to the agency, "We want you to do right."

Mr. SCHEUER. Be sensible?

Dr. LAVE. Be sensible. Rehnquist then says that is an unconstitutional delegation of authority. Rehnquist and Burger together said this was an unconstitutional delegation of authority. I think that is probably correct. In any case the ball is now back clearly in Con-

gress' court. If the administration would like to see benefit cost analysis done of occupational health and safety and some other areas, we need some legislation to do it.

Mr. SCHEUER. Do you have any feeling as to what we ought to be doing in the Clean Air Act that is very shortly coming up for reauthorization?

Dr. LAVE. All of these areas, a general benefit-cost test is well worthwhile, but not a benefit cost test like Executive Order 12291. The Executive order is asking more of the method than it can provde. Cost-benefit analysis wouldn't permit us to identify precisely which project will have the highest net benefits for society.

Cost-benefit analysis can tell us that the benefits are roughly commensurate with the costs; this kind of test is worth while. During the 1960's and 1970's we had an era of rhetoric, of society deciding we could do anything if we only tried. Well, we are in the 1980's and we can't do everything. We have to decide what we can do and not spend society's resources reducing some risk in one area while risks in the other area are running rampant.

Dr. RAMSAY. I think for the Clean Air Act, even just thinking about things rationally would help, thinking about the goals of the act. Are you after better visibility, or are you after health? If you are after better visibility, then maybe it makes sense to keep pollution out of national parks and things like that. If you are after better health maybe it's better to spread pollution around. It would be hard to do a very quantitative cost benefit analysis on all of those things but at least if you sat down and tried to think out the logic of it, you would discover what you were trying to accomplish with the legislation, which is not clear to everyone right now.

Dr. RICHMOND. Let me try two short answers. I agree with Dr. Lave in terms of the recent decision, the ball is back in your court. Second question, second part, I guess I feel very strongly the need for a very comprehensive utilization somehow across Congress, of the implementation of risk analysis type methodologies. I don't know how beyond that to recommend it be implemented other than not developing another agency to mandate it. I think there are hints already that there are ways of doing it. But we have to look broadly in terms of what the real problems are and try to get our hands around the ones that are most severe, because it's obvious that if we drive one into the ground so we know the problems to the nth decimal place it wouldn't do us in the final analysis much good if others are ignored.

Dr. LAVE. Can I add one word? You asked Congressman Ritter about where they should be done? Can I say a word about that? I think one of the major failures of modern environmental legislation is NEPA. Before you could promulgate a regulation you have to do an environmental impact statement. Every agency now does that; the environmental impact statement is done by a group that has no connection with the regulator. That environmental impact statement has no function but to slow down the analysis and promulgation of the legislation. That is terrible. It's a waste of society's resources. The same thing could easily happen with risk analysis. If you mandate some agency to do it, outside contractors will get new work but no one will look at the analysis; it will not contribute. Risk analysis has got to be done in the agency in

tandem with their decisions. It has to inform the decisionmaker each step along the way. Unless that's done I am completely opposed to doing it, because it's just more redtape. We have far too much right now.

Mr. SCHEUER. I am going to thank the gentlemen for their truly stimulating testimony. I could go on myself for another hour but in deference to the time and your patience, I will yield.

Mr. FUQUA. Thank you, all of you, for what has been expressed as a very stimulating discussion and testimony. I think we have identified some problems. I am not sure that we have all of the answers, but you have been most helpful to us in some very important issues concerning risk analysis. I thank you very much. It's been most helpful.

[Whereupon, at 5:20 p.m., the hearing was adjourned.]

APPENDIX I

QUESTIONS AND ANSWERS SUBMITTED FOR THE RECORD

ROBERT A. ROE, N.J.
GEORGE E. BROWN, JR., CALIF.
JAMES H. SCHEUER, N.Y.
RICHARD L. OTTINGER, N.Y.
TOM HARKIN, IOWA
MARILYN LLOYD BOUQUARD, TENN.
JAMES J. BLANCHARD, MICH.
DOUG WALGREN, PA.
RONNIE G. FLIPPO, ALA.
DAN GLICKMAN, KANS.
ALBERT GORE, JR., TENN.
ROBERT A. YOUNG, MO.
RICHARD C. WHITE, TEX.
HAROLD L. VOLKMER, MO.
BILL NELSON, FLA.
STANLEY N. LUNDINE, N.Y.
ALLEN E. ERTEL, PA.
BOB SHAMANSKY, OHIO
RALPH M. HALL, TEX.
DAVE MCCURDY, OKLA.
MERVYN M. DYMALLY, CALIF.

LARRY WINN, JR., KANS.
BARRY M. GOLDWATER, JR., CALIF.
HAMILTON FISH, JR., N.Y.
MANUEL LUJAN, JR., N. MEX.
HAROLD C. HOLLENBECK, N.J.
ROBERT S. WALKER, PA.
EDWIN B. FORSYTHE, N.J.
WILLIAM CARNEY, N.Y.
MARGARET M. HECKLER, MASS.
F. JAMES SENSENBRENNER, WISC.
VIN WEBER, MINN.
JUDD GREGG, N.H.
RAYMOND J. MCGRATH, N.Y.
JOE SKEEN, N. MEX.
CLAUDINE SCHNEIDER, R.I.
JIM DUNN, MICH.
BILL LOWERY, CALIF.

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DARRELL R. BRAMBOOMER
ANTHONY C. TAYLOR
THOMAS F. GRUMBLY

GERALD E. JENKS
MINORITY STAFF DIRECTOR

July 8, 1981

Dr. Lester Lave
The Brookings Institution
1775 Massachusetts Avenue, N.W.
Washington, D.C. 20036

Dear Dr. Lave:

I want to thank you for your excellent testimony on societal risks of energy systems before the Committee on Science and Technology on June 18, 1981.

One of the Committee's senior Members, Congressman Tom Harkin, was unable to attend the hearing because of a conflict with other commitments. Mr. Harkin is extremely interested in the issues raised at the hearing and has submitted additional questions for the witnesses.

The Committee would appreciate receiving your response to the enclosed questions at your earliest convenience. If you require further clarification, please feel free to call Dr. Ezra Heitowit of the Committee staff at (202) 225-2526.

Thank you for your cooperation.

Sincerely,

DON FUQUA
Chairman

DF:Hms
Enclosure

The Brookings Institution

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Economic Studies Program

July 15, 1981

The Honorable Don Fuqua
Chairman, Committee on Science and Technology
U.S. House of Representatives
Rayburn House Office Building - Suite 2321
Washington, D. C. 20515

Dear Chairman Fuqua:

Attached are the edited transcript and answers to the questions posed by Congressman Harkin.

Please let me know if you have further questions.

Sincerely,

Lester Lave

Lester B. Lave
Senior Fellow

Enclosures

Questions for Dr. Lester Lave

1. The table in your testimony presents direct and system wide occupational health risks of renewable energy technologies and of coal and nuclear fuel cycles. The table indicates that there is a higher risk associated with central station photovoltaics compared to the coal-steam electric fuel-cycle. It is our understanding that the photovoltaic risk estimates are based on data from the 25 kilowatt test facility located in Mead, Nebraska.

If the photovoltaics risk estimate is based on a current test facility, is this a realistic estimate for future full scale commercial photovoltaics systems? Would not the estimate based on the test facility be too high? What qualifications would you place on the photovoltaic risk estimate in the table?

The risk estimates in the table do not include ranges of uncertainty. Should uncertainty ranges or some other qualifications be included for each of the estimates?

2. The economics of nuclear power have changed dramatically from early projections in the 1960's. Given the uncertainty that surrounds economic projections for nuclear power, might not the health and occupational risks associated with the nuclear fuel cycle be equally or even more uncertain?

3. By the next decade, it will be necessary to decommission the older commercial nuclear power plants. It has not yet been determined if these plants, following decommissioning, will be entombed or dismantled, and what decontamination procedures will be used.

To what extent do risk analyses for nuclear power consider the risks following plant decommissioning?

Are there different risks for the various decommissioning scenarios?

Is the risk associated with the dismantling process adequately estimated?

In response to the questions posed by Congressman Tom Harkin:

1. However uncertain are risk estimates based on currently operating facilities, those based on designs or conjectures about future technology are even less certain. The analysis correctly relied on a current installation. That installation is not a commerical facility in terms of its cost, size, or design. However, it provides the best current estimates. As the technology improves, we should expect the risks to be lowered. Certainly, such a facility will not be commerically attractive until there are vast decreases in cost, which will probably bring with them increases in safety.

The range of uncertainty is great about all the estimates in the table. For technologies with which we have had little experience, the uncertainty is greater than the estimate. Just as the risks could be much lower than those estimated, they could be much higher. It is important not to place too great confidence in these risk estimates for solar energy. At the same time, they do provide us the best current estimates and a revealing insight into possible problems.

2. A vast amount of effort has been invested in estimating the effects of low level exposure to ionizing radiation and in investigating accident risks from nuclear facilities during the last twenty years. There is little indication that the estimated risks have increased with the new knowledge. They were estimated to be small and continue to seem small. The principal qualification comes from the risks associated with nuclear proliferation. Unfortunately, there

seems to be almost nothing the United States can do to slow the proliferation of nuclear technology that could be used for weapons.

3. The table displays calculations for the risks associated with decommissioning a commerical reactor. While many reactors have been decommissioned, no commerical size reactor has been. Thus, while there is relevant information, there is still uncertainty. The risks shown in the table for decommissioning are extremely small. Conceivably, unforseen problems could arise which would raise these estimates, although they are still likely to be small.

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July 8, 1981

Dr. William Ramsay
Center for Energy Policy Research
Resources for the Future
1755 Massachusetts Avenue
Washington, D.C. 20036

Dear Dr. Ramsay:

I want to thank you for your excellent testimony on societal risks of energy systems before the Committee on Science and Technology on June 18, 1981.

One of the Committee's senior Members, Congressman Tom Harkin, was unable to attend the hearing because of a conflict with other commitments. Mr. Harkin is extremely interested in the issues raised at the hearing and has submitted additional questions for the witnesses.

The Committee would appreciate receiving your response to the enclosed questions at your earliest convenience. If you require further clarification, please feel free to call Dr. Ezra Heitowit of the Committee staff at (202) 225-2526.

Thank you for your cooperation.

Sincerely,

DON FUQUA
Chairman

DF:Hms
Enclosure

Questions for Dr. William Ramsay

1. The economics of nuclear power have changed dramatically from early projections in the 1960's. Given the uncertainty that surrounds economic projections for nuclear power, might not the health and occupational risks associated with the nuclear fuel cycle be equally or even more uncertain?

2. By the next decade, it will be necessary to decommission the older commercial nuclear power plants. It has not yet been determined if these plants, following decommissioning, will be entombed or dismantled, and what decontamination procedures will be used.

To what extent do risk analyses for nuclear power consider the risks following plant decommissioning?

Are there different risks for the various decommissioning scenarios?

Is the risk associated with the dismantling process adequately estimated?

Resources for the Future
1755 Massachusetts Avenue, N.W.
Washington, D.C. 20036

July 21, 1981

Congressman Don Fuqua
Chairman
Committee on Science and Technology
U.S. House of Representatives
Suite 2321
Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Fuqua:

Enclosed are my answers to the supplementary questions of Congressman Harkin, sent to me July 8.

Sincerely yours,

William Ramsay
Senior Fellow

WR/ab

202/328-5000 Cable: Resources

Answers to Congressman Harkin's questions:

1. The economics of nuclear power have changed dramatically from early projections in the 1960's. Given the uncertainty that surrounds economic projections for nuclear power, might not the health and occupational risks associated with the nuclear fuel cycle be equally or even more uncertain?

The uncertainties in health risks involved in the nuclear fuel cycle are, I agree, an even more serious drawback to an overall analysis of the social costs of nuclear power than the factors reflected in the current debate over economic costs. While it is true that the economic factor was probably underestimated in cost calculations for earlier plants, I think many studies, and especially the review done for the public utilities commission in NY State by its staff, show that nuclear power, on a purely financial basis, is still often very competitive with coal. But the health costs are another matter. I myself used a rather narrow range surrounding the Rasmussen value of 0.02 death per reactor year in my earlier book "Unpaid Costs of Electrical Energy" (Baltimore, Johns Hopkins Press for Resources for the Future, 1979). By the time we got around to finishing up the book "Energy in America's Future" (1979), I perforce felt I had to say that we needed to look at much wider limits, mainly as a result of the Lewis report--but also reflecting the events at Three Mile Island. This revision made the range of deaths from traceable nuclear accidents fall right up there in the same range with coal. I emphasixe the word "range" because the uncertainties are still very great.

If we also consider uncertainties like the proliferation of nuclear weapons as a result of commercial nuclear power, then the possible "health effects" could be indeed enormous, as I have emphasized many times in my writings.

2. By the next decade, it will be necessary to decommission the older commercial nuclear power plants. It has not yet been determined if these plants, following decommissioning, will be entombed or dismantled, and what decontamination procedures will be used.

To what extent do risk analyses for nuclear power consider the risks following plant decommissioning? Are there different risks for the various decommissioning scenarios? Is the risk associated with the dismantling process adequately estimated?

I am not really familiar with the risk analyses done for the various decommissioning scenarios so I cannot comment on their adequacy. Past risk analyses for nuclear fuel cycles may or may not have included risks of decommissioning. But as I emphasized in my testimony, the main problem is: do you discount risks occuring in the future? When you are treating risks in the year 30,000 A.D., it seems pretty evident that you do. Otherwise you seem to get into terrible contradictions. With nuclear

plant decommissioning, one is talking about a nearer time, 30 years into the future. But that 30 years is still far enough away that with most reasonable discount rates one would not have to pay too much attention to the risks. I am not awfully happy with the device of discounting risks, but I do not see any reasonable way out of it, as I have emphasized in some of my writings.

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MINORITY STAFF DIRECTOR

July 8, 1981

Dr. Chester R. Richmond
Associate Laboratory Director for
Biomedical and Environmental Sciences
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

Dear Dr. Richmond:

I want to thank you for your excellent testimony on societal risks of energy systems before the Committee on Science and Technology on June 18, 1981.

One of the Committee's senior Members, Congressman Tom Harkin, was unable to attend the hearing because of a conflict with other commitments. Mr. Harkin is extremely interested in the issues raised at the hearing and has submitted additional questions for the witnesses.

The Committee would appreciate receiving your response to the enclosed questions at your earliest convenience. If you require further clarification, please feel free to call Dr. Ezra Heitowit of the Committee staff on (202) 225-2526.

Thank you for your cooperation.

Sincerely,

DON FUQUA
Chairman

DF:Hms

Questions for Dr. Chester Richmond

1. The economics of nuclear power have changed dramatically from early projections in the 1960's. Given the uncertainty that surrounds economic projections for nuclear power, might not the health and occupational risks associated with the nuclear fuel cycle be equally or even more uncertain?

2. By the next decade, it will be necessary to decommission the older commercial nuclear power plants. It has not yet been determined if these plants, following decommissioning, will be entombed or dismantled, and what decontamination procedures will be used.

To what extent do risk analyses for nuclear power consider the risks following plant decommissioning?

Are there different risks for the various decommissioning scenarios?

Is the risk associated with the dismantling process adequately estimated?

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July 17, 1981

Mr. Don Fuqua
Chairman
Committee on Science and Technology
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Fuqua:

Enclosed are responses to the questions raised by Congressman Tom Harkin which you sent to Dr. Richmond this week. He was leaving on vacation at the time your letter arrived and had a staff member compile the responses.

Please contact us for any copies you may wish to receive that were referenced. We'll continue to supply information in more detail if you so desire.

Sincerely,

Lindy Norris

Lindy Norris
Secretary to C. R. Richmond
Associate Director for Biomedical
and Environmental Sciences

Enclosure

1. The economics of nuclear power have changed dramatically from early projections in the 1960's. Given the uncertainty that surrounds economic projections for nuclear power, might not the health and occupational risks associated with the nuclear fuel cycle be equally or even more uncertain?

   Part of the cost of nuclear fuel cycle facilities involves the cost of safety features. Thus costs are related to risks but risks are not determined by economic projections. Risk methodologies for nuclear fuel cycles have actually improved since the 1960's. Given a specific reactor design with an associated degree of risk, the economics will be influenced by various other market factors. Uncertainties in economic projections do not translate into uncertainties in public and occupational health risks. There will always be basic safety features such as emergency core cooling that will always be required regardless of temporal costs. Marginal costs associated with degree of risk at a particular point in time may be the subject of continued debate.

2. By the next decade, it will be necessary to decommission the older commercial nuclear power plants. It has not yet been determined if these plants, following decommissioning, will be entombed or dismantled, and what decontamination procedures will be used.

   To what extent do risk analyses for nuclear power consider the risks following plant decommissioning?

   Risk assessments for nuclear fuel cycles have generally not included risks after decommissioning because such risks are considered to be much less than those associated with operating facilities.

   ORNL has been developing detailed protocols for monitoring after decommissioning to ensure that exposures are below guidelines. A report is available - NUREG/CR-2082. The guidelines will be developed by NRC. At present it appears that the guideline will be about 10 mr/yr. Such guidance is suggested in the Draft Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities issued by the NRC in January 1981. Thus the plan is to ensure that risks are low by actual monitoring. It may be possible through monitoring and supplemental analysis that exposures can never actually approach guidelines. In fact, it appears that exposures to the public will be much lower than during operation of the facilities.

   Are there different risks for the various decommissioning scenarios?

   The highest individual risks will be to the people carrying out the particular scenario. The exposures involved will not be greater than existing regulations. These regulations correspond to an upper limit on risks that are possible. Within regulatory constraints, the risks will of course depend upon the particular procedures carried out. For example, if a fuel cycle component is completely dismantled, occupational exposures will be greater than for entombment. See response to next question.

Is the risk associated with the dismantling process adequately estimated?

Pacific Northwest Laboratory has conducted detailed analyses of various dismantling options including calulation of doses to personnel. Given these dose estimates and risk estimates as provided in the BEIR, ICRP or UNSCEAR reports, it is possible to calculate the risks associated with dismantling. Reports are available as NUREG/CR documents for various nuclear fuel cycle components. In these reports occupational safety as well as technology and costs have been considered.

APPENDIX II

Additional Material Submitted for the Record

ASSESSING ENERGY RISKS

BY
CHRIS WHIPPLE

PROVIDED TO THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES;
HEARINGS ON SOCIETAL RISKS OF ENERGY SYSTEMS

JUNE 18, 1981
WASHINGTON D.C.

ASSESSING ENERGY RISKS

Chris Whipple*

ABSTRACT

Energy risks analyses are conducted for a variety of purposes: to evaluate alternative energy sources, sites, research strategies, and policies. Frequently the information provided by generic analyses of energy risks is difficult to apply to these real issues. The mismatch between available and desired risk information can occur for several reasons: often risk studies emphasize aggregate effects, while policy decisions depend significantly on distributional effects. The importance and difficulty of this mismatch increases with the complexity of the issue treated.

INTRODUCTION

In recent years, substantial effort has been expended to estimate or measure the risks of energy production. The results of this work appear to be converging within fairly broad uncertainty limits for many risks; however, there remain intuitively important energy system impacts which cannot presently be described except in qualitative terms. An excellent survey of part of this literature has recently been issued by A.V. Cohen and D.K. Pritchard of the U.K. Health and Safety Executive (1); this report summarizes the risks of producing electricity from oil, coal and uranium. As this and other reports (2,3) have noted, substantial complexity and, often, confusion surround the comparison of energy risks for a number of reasons, including the problems of comparing qualitatively different effects and difficulties in reconciling the generic risks of a specific energy facility with the risks from a whole system of energy facilities.

---

*Technical Manager, Energy Study Center, Electric Power Research Institute, Palo Alto, California.

The purpose of this paper is to examine alternative viewpoints for assessing and comparing energy risks. Specifically, the issues for which energy risk information is relevant (e.g., siting, selecting energy sources, setting R&D policy, etc.) will be considered against present capabilities to analyze energy risks. Within this context, estimates of certain energy risks are provided. The thesis underlying this description is that, frequently, one finds a mismatch between the form and type of information available from energy risks studies and the information desired by those facing a decision about energy sources. The approach taken here will be to briefly describe the prevailing approach to analysing and reporting energy risks; then to consider how applicable such results are as inputs to several types of energy issues.

ASSESSING GENERIC ENERGY RISKS

The most common approach to the analysis of energy risks is to consider the likely health and safety impacts of an energy facility of standard size, and to include risks due to the full cycle of activities needed for the operation of such a facility. Thus, we frequently find comparisons of the effects of 1000 MWe generating stations, including estimates of the risks associated with mining and transporting the required fuel and operating the power plant. These are more or less minimal requirements for an energy risk analysis. Several studies (4,5) have gone much further to try to account for such other effects such as the acquisition of materials for plant and fuel cycle facilities, the risks of construction, waste disposal, decommission, and several other effects which have proven very elusive to quantify.

The results of the analysis of each phase of energy production and delivery are usually segregated by the type of impact, i.e., occupational effects are noted separately from public consequences, as are accidents and disease impacts. For example, Table 1 indicates the estimated annual occupational fatalities from coal, oil, and nuclear power plants. These estimates are not totaled because the fatalities are not strictly comparable, due to the fact that accidental fatalities will, on average, lead to many more years of life shortening than will occupational deaths due to either pneumoconiosis or cancer. One can see from these estimates that coal is thought to cause several times as many occupational deaths than oil or nuclear, although there is enough uncertainty to cause the estimates to overlap one another.

Table 1*

ANNUAL OCCUPATIONAL FATALITIES OF PRODUCING ELECTRICITY FROM A COAL, OIL, OR NUCLEAR POWER PLANT OF 1000 MWe (75% load factor)

	Coal	Oil	Nuclear
Fuel Extraction			
Accidental deaths	0.33-2.13	0.1-1.28	0.05-0.43
Pneumoconiosis, etc.	0-7.0	-	-
Cancer deaths	not avail.	not avail.	0.015-0.45
Fuel Transport			
Accidental deaths	0.055-3.75	0.03-0.34	0-0.011
Power Plant Operations			
Accidental deaths	0.01-0.15	0.01-0.038	0.01-0.2
Cancer deaths	not avail.	not avail.	0.024-0.21**

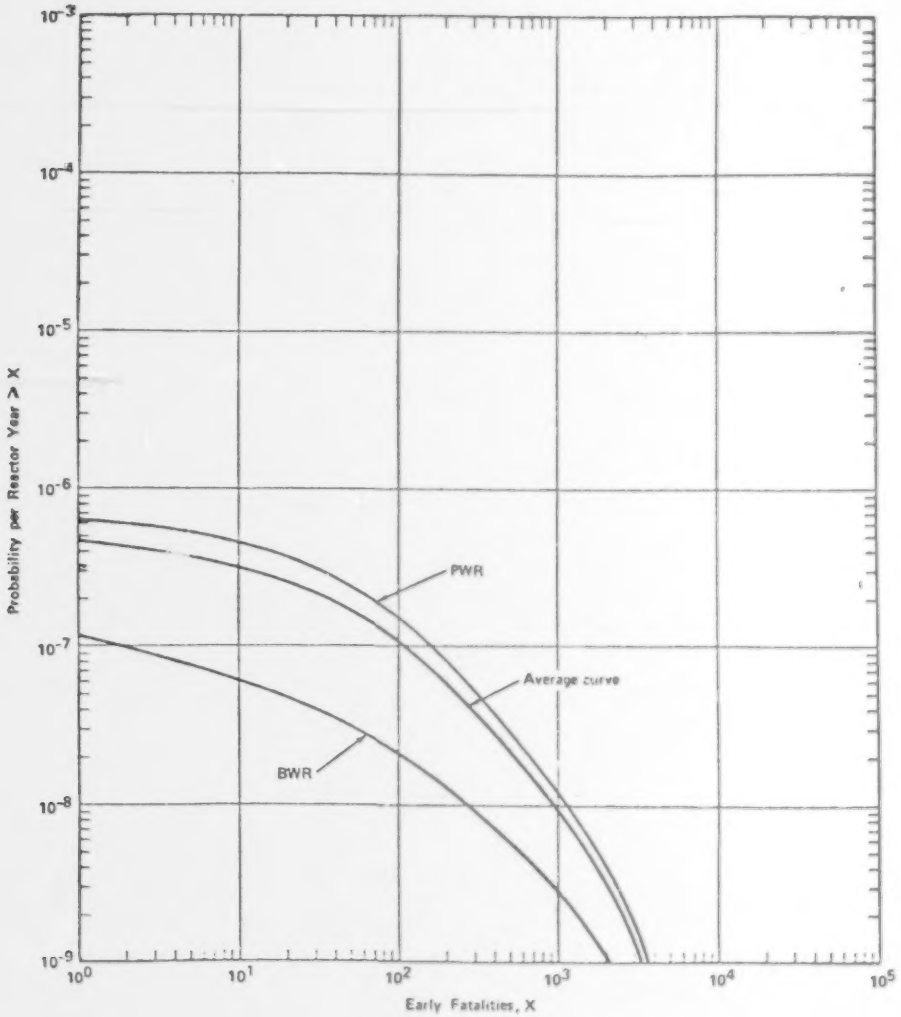
*Source: Reference 1. In this report, the sources of these estimates are provided, as are comments regarding the range of applicability of the estimates.

**Does not include waste disposal.

In general, other estimated risks of energy production are presented in a similar format. Public health and safety effects are further separated depending on whether the uncertainty is due to our limited knowledge of the effect, or whether the effect itself is probabilistic in nature. For example, the public health effects of sulfur from power plants are estimated (1) to fall between 0-110 fatalities per 1000 MWe plant per year (coal or oil at 75% load factor). The estimated risks of nuclear power plants are described by a curve relating probability and consequence as illustrated in Figure 1. (6) Similar estimates are provided in reference 6 for latent fatalities, genetic effects, thyroid nodules, and for property damage.

REPORTING ENERGY RISKS

As the above comments indicate, at present, most energy risk analyses provide detailed estimates of different health



Probability Distribution for Early Fatalities per Reactor Year

Note: Approximate uncertainties are estimated to be represented by factors of 1/4 and 4 on consequence magnitudes and by factors of 1/5 and 5 on probabilities.

FIGURE 1

effects without attempting to provide an overall index for each energy source. This represents somewhat of a mixed blessing for those wishing to use the results of a risk comparison. To someone wishing to know "which is safer--coal, oil, or nuclear?" the answer is not readily apparent from several pages of tables and a number of probability-consequence curves. While this question is clearly a major reason for studying energy risks, its answer requires that dissimilar effects be expressed in comparable units. Analysts have been reluctant to make such comparisons for several reasons. The most important of these is that the expression of different types of risk on a common scale requires conversion factors or weights; these weights are judgments of value rather than of fact, and will differ depending upon who does the appraisal.

For example, the postulated impacts of a serious nuclear plant accident include both acute fatalities as well as latent cancer fatalities. The latent cancers are likely to occur 20 to 40 years after an accident; this yields the age effect described above. Verification of latent cancer deaths following an accident is likely to be impossible given the large numbers of cases projected even if no accident occurs. The influence of this uncertainty is important in two ways. First, the assumptions upon which radiation induced latent cancer deaths are estimated are often conservative (in that they are upper bound estimates). Second, generally no credit is given for future improvements in the treatment of cancer. In addition, a common practice in cost-benefit analyses is to discount future costs. For these and other reasons, it has been argued that the social cost of an acute fatality in a reactor accident is greater than the cost of the somewhat hypothetical latent cancer. Litai, in his thesis (7) proposed that the value (or cost) of a latent fatality is about one-thirtieth that of early fatalities. A recent Nuclear Regulatory Commission report prepared by the Advisory Committee on Reactor Safeguards, proposed a ratio of five to one.

Even this simple example serves to illustrate the point that comparisons of different technologies requires trade-offs between dissimilar effects. In practice, the trade-offs that must be considered are often far more difficult than that between acute and latent fatalities. For example, a coal-nuclear comparison involves ranking the sociological impact of coal boom towns and the impacts of coal use on air quality against low probability-high consequence nuclear accidents. Methods for making these trade-offs have been proposed, (9) but in practice, risk analysts have been reluctant to use them because they tend to be complex, and because they are often less defensible than an analysis of impacts. On balance, an aggregated index for the effects of energy technologies can mislead as easily as it can simplify, and important information about who is at risk, and about analytical uncertainties is often lost.

Finally, risk estimates change in time as the state of risk analysis advances, and as more work is conducted and more data collected. As this information is developed and as risk analyses are revised and critiqued (see 3 and 4), it is helpful not to confuse questions of fact with questions of value.

RISK ANALYSIS APPLICATIONS

To illustrate the point that real issues involving energy risks often require specialized analyses, several examples will be given, in order of increasing complexity. An additional point of these examples is to indicate the difficult value judgments that risk decisions require, and to indicate how those values can shift depending upon the perspective brought to the issue.

Controlling Risk at the Margin

Perhaps the simplest and most common use of risk analysis is to evaluate alternative safety or emission standards for a specified technology. For example, one may wish to evaluate alternatives for controlling occupational exposure to radiation in nuclear power plants. Risk studies such as those summarized in Table 1 provide an estimate of the total radiation dose to the plant workers. To a first approximation, the effect of alternative control strategies on total dose can be estimated. Changes in total risk (that is, the number of cases of cancer in the lifetime of exposed workers) are assumed to be proportional to changes in dose. this may serve as a valid societal perspective for evaluating control alternatives, but it is not the only viewpoint. From the workers perspective, the issue is not the aggregate risk, but rather, the risk to each individual worker. As has been noted (10), the risks of mining coal and uranium appear to be roughly comparable but, because the energy density of uranium is so much higher than that of coal, fewer uranium miners are needed per plant-year than are coal miners. This explains the differences in Table 1.

For purposes of societal decision making, it is not at all clear which is the preferable way of expressing these risks. It has been argued (3) that, because occupational risks are compensated to some degree, their social costs are included in the price of the fuel, and that the appropriate measure is the risk rate. By this perspective, one is indifferent between coal and nuclear based on mining risk. But often the viewpoint taken is that which examines total social impacts. Under this perspective, nuclear is preferable.

Siting

Power plants sites are selected by comparing the impacts of a plant at several alternative sites against a number of dimensions of impact. The issues include land use, public health and safety, socioeconomic impacts, demands on transportation systems, and so on. For many siting cases, the major issue is not the magnitude of the impacts at alternative sites, but instead, how the social costs are distributed. The familiar problem of siting airports is illustrative--everyone wants an airport, but nobody wants it near them. The central task in these cases is finding a political solution to a problem of distributional equity; determining what is fair is the heart of the issue. But to attempt to define the optimal site, based on a risk analysis of the alternatives, is to misunderstand the issue.

Systemic Impacts of Energy Facilities

Although it sounds straightforward, finding a risk analysis which considers the risks of energy alternatives in a physically realizable context is often difficult. Wilson (11) has summarized several issues in performing such an analysis; he correctly points out a number of counter-intuitive features found from his analysis.

The issue here is whether the generic assessment of a power plant (plus fuel cycle effects) accurately reflects the social impacts of adding a new power plant to the supply system within a region. Clearly, this would be the case if a new plant were added, while, simultaneously, operation of the existing plants continued as before. But in practice a utility operates only enough plants to meet demand, so the operation of a new power plant will lead to the curtailment of operations at other, older plants. From this perspective, the issue becomes the risk accompanying the production of a fixed number of kilowatt hours, rather than the risk of a single power plant. Using modifications of power plant risk estimates developed at Brookhaven National Laboratory, Wilson finds that a new 1000 MWe coal or nuclear plant will reduce rather than increase risk. This occurs because electricity generated from a new plant will replace power generated by older fossil-fueled plants. The risk reduction occurs because new coal plants and nuclear plants are sited more remotely and built to more stringent environmental and safety standards than the present mix of fossil-fueled plants.

This systemic view of electricity-production risks is valid, but only in the very short term. Over the longer term, new generation capacity will be added, primarily to meet load growth rather than to replace existing capacity. The extension of this systemic view to longer-term energy

risks is quite difficult because it requires projection and assessment of both supply and demand, taking uncertainty into account. One issue in this regard is the adequacy of currently planned energy-production capacity. If public and political perceptions are that the supply industries are "crying wolf," a real shortfall could develop; the impacts on health and safety of this cannot be predicted by current risk-assessment methods. If, alternately, people vigorously conserve energy, an alternate set of economic and risk effects would result. It is also possible that anticipation of shortfall could lead to a relaxation of environmental or safety standards to permit more rapid plant construction. This would produce a third set of effects.

National and International Energy Issues

The above discussion of the difficulty of predicting the long-term systemic impacts on risk of energy decisions applies as well to the problem of formulating national energy policies. But on the national level, there are additional complexities. There are important energy policy issues which can often be neglected when a decision concerning only one plant is required; these same issues may dominate national energy policy deliberations. Such issues include:

- the relationship between nuclear power and nuclear weapons proliferation,
- fossil fuel use and CO_2 buildup in the atmosphere,
- the effects of energy imports on supply security, U.S. security, foreign policy, and balance of trade,
- the impact of energy cost on the competitiveness of U.S. products in global markets,
- the influence of perceptions of supply reliability on energy intensive investments, and
- determining equity between producer profits and consumer costs, including an appraisal of the social impacts of rising energy costs.

While aspects of each of these issues can be treated quantitatively, good energy decisions require a judgmental understanding of all these factors.

ENERGY DECISION MAKING

For national energy issues such as the development of synfuels, the breeder reactor, or the future of nuclear

power, energy risk analyses are only one factor of many that need to be considered. It often appears that energy production risks are used as a surrogate for the full social impacts of energy production. This is implicit in comparisons of energy risks, in which the implied premise is that nuclear should be accepted, given that it is apparently safer than coal.

Ideally, energy policy decisions would consider relevant factors such as risk in proportion to the probability and importance of their anticipated effect. But it seems unlikely that this happens when the effects are not quantified to comparable levels of detail, or when the uncertainties vary substantially between different risks. The task of the policymaker or informed citizen is difficult: What is required is an integration of quantitative estimates of some risks with highly uncertain intuitive estimates of other risks in a way which does not overemphasize either set of estimates.

This issue lies at the center of the national energy policy debate on the degree to which nuclear power and coal use would be expanded. Whether society is safer on balance with abundant energy, and the associated production risks, or with less energy, and perhaps greater indirect risks due to oil imports or poor performance of the national economy, is the issue. The comparison of relatively well-quantified production risks, with intuitively estimated indirect risks is difficult, and is clearly beyond the scope of most risk studies.

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Biographical Note

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RISKS IN PERSPECTIVE: NATURAL, OCCUPATIONAL, AND DE MINIMIS

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RISKS IN PERSPECTIVE: NATURAL, OCCUPATIONAL, AND *DE MINIMIS*

C. R. Richmond

Good morning ladies and gentlemen. It is my pleasure to be able to speak to you on the subject of "Risks in Perspective." I intend to discuss some of the risks which arise from natural and occupational sources and the most important concept called *de minimis* risk, which means relatively harmless or small enough to be of minimum concern. It is obvious that there is a high level of interest, both nationwide and internationally, in the subject of risk. I believe it is most important to discuss comparative risks and to place risks in proper perspective, especially when one is dealing with the translation of information from the scientific and technical domain to that of the general public. John Hanley, Monsanto's chairman and chief executive officer, recently wrote as follows:

> "People today eagerly seek assurances of safety. Because of that, unproven theories and concepts developed by toxicologists in their labs quickly become accepted as fact and are put to practical use - too frequently in government regulations. The dangers in this situation are obvious: misunderstanding, misinterpretation, and misapplication."

He continues:

> "The public is not an unthinking mob, and it can understand the facts if properly presented. The problem is that scientific facts are not always explained well enough or put in proper perspective. It is a fact that apple seeds can kill you - but what does that fact mean unless placed in perspective?"

I believe it is imperative that the scientific community transmit more useful information concerning risk methodology, comparative risk, and risk assessments to the general public. We need to learn how to make this information more understandable and, therefore, useable by the public.

Several members of Congress are very active in this rapidly developing field of risk. One is Representative Donald Ritter (D-PA) who, incidentally, was trained as a metallurgical engineer. Another is Representative William Wampler (R-VA), who looks toward the area of risk to make "some sense out of the hodgepodge of regulatory systems that we find daily causing more and more confusion and chaos in our land." Representative Wampler has sponsored a bill establishing a formal tie

between regulatory agencies and a new fifteen-member "National Science Council." Such a system might prevent regulators from "bending science." Representative Ritter would require regulators to make objective comparisons among the risks of various actions. This would require the addition of some kind of risk comparison treatment in a regulatory reform bill introduced this year. Mr. Ritter introduced HR 4939 into the first session of the 96th Congress. His bill would provide for a federal mechanism within the Office of Science and Technology Policy for assessing the comparative risks involved and actions in scientific technological and related fields.

The Senate is now considering the Nuclear Safety Research and Development Act of 1980 (S 2884), a bill that would require the Department of Energy to define the risks in design and operation of nuclear power plants, to develop cost-benefit design changes to reduce risks, and to develop methods and designs to improve operator performance. Provisions of the original bill requiring comparative analyses of the risks of all electrical energy generating sources was removed because of opposition from antinuclear groups. The already-passed House legislation (H 7865) includes the need for comparative risk analysis.

These are several examples of some of the legislation which is now appearing in Congress concerning the rapidly growing area of risk and risk assessment.

According to Norman Cousins, had history been governed by cost-benefit analysis, Columbus would have been a gondolier. This story is probably a reflection of similar attitudes on this topic that are being generated in many quarters of our society today. Stated simply, the concern is that no risk is the greatest risk of all.

Natural Risks

I would now like to discuss with you some of the risks to which we are all exposed. There are various ways to measure the risk or detriment from a given activity, be it manmade or the result of natural phenomena, but perhaps the easiest endpoint to record is that of death. Because everyone will eventually die, the probability of death for everyone is one. What is important are the causes of death and how these causes vary as a function of time. Figure 1 gives the leading causes of death for individuals in the United States for 1900 and 1970. Note that in 1900 the major causes of death were the so-called diseases of biotic etiology or more simply stated, infectious diseases. Heart disease was number 4 and cancer number 8 in incidence in 1900. However, by 1970 the major cause of death was heart disease followed closely by cancer. Several things should be apparent, one of which is that the control of infectious diseases primarily through public health measures has made the U.S. population more prone to diseases of the aged, especially cancer and heart disease. It is also apparent that as progress is made in reducing the incidence of heart disease, cancer will be the number 1 cause of death.

LEADING CAUSES OF DEATH IN THE UNITED STATES IN DECREASING ORDER OF DEATH RATE

1900	1970
TUBERCULOSIS	HEART DISEASE
PNEUMONIA	CANCER
DIARRHEA AND ENTERITIS	CEREBRAL HEMORRHAGE
HEART DISEASE	ACCIDENTS
CEREBRAL HEMORRHAGE	INFLUENZA AND PNEUMONIA
NEPHRITIS	CONGENITAL DISEASES
ACCIDENTS	DIABETES
CANCER	ATHEROSCLEROSIS
BRONCHITIS	CIRRHOSIS
DIPTHERIA	EMPHYSEMA

SOURCE: VITAL STATISTICS OF THE UNITED STATES.

Figure 1

Figure 2 gives the leading causes of all deaths for U.S. citizens of all ages for the year 1975. These causes are ranked in decreasing order of risk. Heart disease heads the list with an annual risk of death of 3.36×10^{-3}, which is 3.36 per thousand, or 336 per 100,000 or 10^5 people. Cancer is number 2 on the list, and currently there are about 400,000 cancer deaths per year. The first four entries in this table represent a large fraction (about 73%) of all deaths which is shown in Figure 3. There were 1.89 million deaths in the U.S. in 1975 carrying an annual risk of death of 8.89 per thousand, or almost 900 per 100,000 people. Suicide and homicide made the top ten in 1975. These data are not adjusted for age. For some age groups, for example young males, accidents may be the leading cause of death.

Figure 4 shows the annual risk of death for various diseases in the United States for 1975. Note first that the general causes of death have not changed significantly from 1970. Deaths from cancer, that is malignant neoplasms, are 1.7×10^{-3} as an annual risk. This means 1.7 per thousand deaths as compared with about 9 deaths per thousand from all causes. Therefore, about 20% of all causes of death are related to cancer. Figure 5 shows additional causes of death in decreasing order of annual risk. Peptic ulcer, for example, has a risk of about 3 per 100,000, or a death risk about 100 times smaller than that of heart disease.

Figure 6 shows the risk of being your age. The data are for U.S. white males for the year 1975. We all know that the probability of death increases as a function of age. Insurance companies are expert in predicting, at least on a statistical basis, how long each of us will live. For a white male age 60 in 1975, the probability of death was .02, or about one chance in 50. This information can be converted to that shown in the last column: that is, the time required in minutes for a one-in-a-million chance of death. It turns out that for our hypothetical white 60-year-old male the one-in-a-million chance of death comes about every 26 minutes, or about the time required for me to present this paper.

I mentioned earlier that cancer is a disease of the aged. Although it is a serious human disease, we should realize that if there were no cancer, human life span on the average would increase by relatively small amounts. For example, as shown in Figure 7 the average life expectancy for an individual age 65 would be extended by 1.4 years if there were no cancer and additional expectancy for a person age 35 would be 2.5 years. Cancer shortens lives of many people, but when taken in aggregate, the reduction in life span from cancer is relatively small.

Much has been said in recent years concerning the importance of so-called environmentally associated or environmentally related cancer. In fact, there is much misinformation in this area. The original arguments of Higginson have been misinterpreted and misrepresented to

LEADING CAUSES OF ALL DEATHS USA – 1975 – ALL AGES (I)

CAUSE	NUMBER OF DEATHS	DEATH RATE/10^5 PEOPLE	ANNUAL RISK OF DEATH
HEART DISEASE	716,215	336	3.36×10^{-3}
CANCER	365,693	172	1.72×10^{-3}
STROKE (CV DISEASE)	194,038	91	9.10×10^{-4}
ALL ACCIDENTS	103,030	48	4.80×10^{-4}
PNEUMONIA	51,387	24	2.40×10^{-4}
DIABETES MELLITUS	35,230	17	1.70×10^{-4}

Figure 2

LEADING CAUSES OF ALL DEATHS USA – 1975 – ALL AGES (II)

CAUSE	NUMBER OF DEATHS	DEATH RATE/10^5 PEOPLE	ANNUAL RISK OF DEATH
CIRRHOSIS OF LIVER	31,623	15	1.50×10^{-4}
ARTERIOSCLEROSIS	28,887	14	1.40×10^{-4}
SUICIDE	27,063	13	1.30×10^{-4}
HOMICIDE	21,310	10	1.00×10^{-4}
EMPHYSEMA	18,795	9	9.00×10^{-5}
GRAND TOTAL*	1,892,879	889	8.89×10^{-3}**

*ALL CLASSES NOT INCLUDED IN TABLE.
**OR 8890 CHANGES IN A MILLION OF DYING IN 1975.

Figure 3

ANNUAL RISK OF DEATH FROM VARIOUS DISEASES (I)

• ALL CAUSES	8.96×10^{-3}
• HEART DISEASES	3.39×10^{-3}
• MALIGNANT NEOPLASMS	1.74×10^{-3}
• CEREBROVASCULAR DISEASE	9.18×10^{-4}
• INFLUENZA	2.70×10^{-4}
• DIABETES	1.68×10^{-4}

MONTHLY VITAL STATISTICS REPORTS, ANNUAL SUMMARY FOR THE U. S., 1975.

Figure 4

ANNUAL RISK OF DEATH FROM VARIOUS DISEASES (II)

LIVER CIRRHOSIS	1.51×10^{-4}
ARTERIOSCLEROSIS	1.37×10^{-4}
INFANT MORTALITY (EARLY)	1.28×10^{-4}
BRONCHITIS	1.19×10^{-4}
CONGENITAL ABNORMALITIES	6.70×10^{-5}
PEPTIC ULCER	3.20×10^{-5}

MONTHLY VITAL STATISTICS REPORT, ANNUAL SUMMARY FOR THE U. S., 1975.

Figure 5

RISK OF BEING YOUR AGE

AGE	PROBABILITY OF DEATH	TIME REQUIRED FOR 10^{-6} CHANCE OF DEATH (MINUTES)
10	0.00027	1950
20	0.00183	287
30	0.00162	325
40	0.00294	179
50	0.00800	66
60	0.02030	26
70	0.04519	12
80	0.10014	5.3

USA, WHITE MALES, 1975

Figure 6

A CURE FOR CANCER WOULD LENGTHEN LIFE BY RELATIVELY SMALL AMOUNTS

AGE	IF NO CANCER, THE FOLLOWING NUMBER OF YEARS WOULD BE ADDED TO THE AVERAGE LIFE EXPECTANCY OF PERSON AT LEFT
35	2.5
65	1.4

SOURCE: KENNEDY INSTITUTE OF ETHICS, GEORGETOWN UNIVERSITY.

Figure 7

the point where many people claim that 70-90% of all cancer cases are environmentally caused. This is, indeed, not the case and it is incorrect to state that exposure to industrial chemicals in the work place or in the outside environment causes 70-90% of all cancers. Figure 8 gives examples for what are believed to be environmentally associated cancers among males of the Birmingham-West Midlands district in the United Kingdom. The defined environmental factors (53%) include tobacco, sunlight, occupational causes, cancers related to tobacco and alcohol, radiation, and iatrogenic; that is, caused by physicians. Note that of the bulk of these defined environmental factors, some 46% are caused by the first three categories; that is, tobacco, sunlight, and occupational. The second major heading listed as presumed environmental factors accounts for 47% of all the cancers in this group. These include dietary, cultural and behavioral life styles and congenital and unknown factors. The life-style-related cancers include those of the stomach and large intestines for both sexes, prostate in males, and breast, ovary, uterine, and cervix cancer in females. Note also that 30%, or almost one-third, of all the cancers is attributable to tobacco. Figure 9 shows similar information for females. In this case the presumed environmental factors account for 76% of the cancers identified in this population group. Occupation in all cancers accounted for only 2% among the females and, as shown previously, 6% for the males.

Let us now look at some of the major accidents and major disasters that have happened in the U.S. since 1900. The effects of tornadoes are well known to the residents of Illinois. Figure 10 shows the 300+ deaths resulting from tornadoes in one day in April 1974. The 1979 air crash at O'Hare airfield claimed 271 lives. This number is relatively small in terms of human lives as compared with the Galveston tidal wave which caused 6,000 deaths.

Occupational Risks

Occupational risks arise from exposure to toxicants or carcinogens in the work place and accidents. Our interest in the subject of risks dates back centuries in some cases. For example, the Romans wrote about the effect of sulphur on individuals and Ramazzini wrote a book in the year 1700 called "De Morbis Artificum," or "Diseases of Workers." In 1775 Percival Pott wrote on the problems of cancer in humans (chimney sweeps) arising from what we now know as complex polynuclear aromatic hydrocarbon compounds. Complex polynuclear aromatic hydrocarbons are carcinogens of concern in fossil fuels. His article, entitled "Chirurgical Observations," was reprinted in the National Cancer Institute Monographs in 1963. In 1557 miners of uranium-bearing ores in the Erz Mountains of central Europe were reported by Agricola to have an unusually high incidence of fatal lung disease. In 1879 Harting and Heese correctly diagnosed the disorder as malignant neoplasia of the lung for miners in the Schneeberg area of

ENVIRONMENTALLY ASSOCIATED CANCER – MALES
BIRMINGHAM WEST MIDLANDS DISTRICT, U. K.

- DEFINED ENVIRONMENTAL FACTORS (53%)

TOBACCO	30	TOBACCO/ALCOHOL	5
SUNLIGHT	10	RADIATION	1
OCCUPATION	6	IATROGENIC	1

- PRESUMED ENVIRONMENTAL FACTORS (47%)

LIFE STYLE, DIETARY	25
LIFESTYLE, CULTURAL	5
CONGENITAL	2
UNKNOWN	15

Figure 8

ENVIRONMENTALLY ASSOCIATED CANCER – FEMALES
BIRMINGHAM WEST MIDLANDS DISTRICT, U. K.

- DEFINED ENVIRONMENTAL FACTORS (24%)

SUNLIGHT	10	OCCUPATION	2
TOBACCO	7	RADIATION	1
TOBACCO/ ALCOHOL	3	IATROGENIC	1

- PRESUMED ENVIRONMENTAL FACTORS (76%)

LIFESTYLE, DIETARY	43
LIFESTYLE, CULTURAL	20
CONGENITAL	2
UNKNOWN	11

Figure 9

LARGEST DISASTERS IN USA SINCE 1900

CLASS / TYPE / LOCATION	DATE	NUMBER OF DEATHS
SHIP		
TITANIC	15 APRIL 1912	1,517
EXPLOSION/TEXAS CITY	16 APRIL 1947	561
AIRCRAFT CRASH AT CHICAGO AIRPORT	25 MAY 1979	271
FLOODS		
GALVESTON TIDAL WAVE	8 SEPT. 1900	6,000
HURRICANES		
FLORIDA	16-17 SEPT. 1928	1,833
TORNADOES		
SOUTHERN AND MIDWESTERN STATES	3 APRIL 1974	307
EARTHQUAKES		
SAN FRANCISCO	18 APRIL 1906	452

Figure 10

Germany. In the early 1930's other investigators reported on the incidence of lung cancer among miners of uranium-bearing ores in the Joachimsthal, Czechoslovakia, and assigned the most probable cause of these cancers to radiation in the uranium mine. We now know that this is the cause and we have additional cases of lung cancer associated with uranium miners in the southwest part of the United States.

In the late 1890's and early 1900's information on the effects of radiation on physicians and physicists began to appear in the scientific literature, and in the 1920's and 1930's information on radium dial painters and individuals given radioactive radium compounds also appeared in literature. In the early 1940's, just after the isolation and identification of plutonium, papers began to appear in journals, such as Radiology and Cancer Research warning others about the potential adverse impact of fission products and plutonium on man. Somewhat prophetically, one of these papers was entitled "Carcinogenic Action of Some Substances Which May Be a Problem in Certain Future Industries."

More recently many additions have been made to the listing of items of concern. These include pitch, shale oil, paraffin, cutting oils, arsenic, chromates, aromatic amines, asbestos, benzene, phenacetin, and mercury.

There is currently much interest in converting coal to gaseous and liquid products. Figure 11 shows information on the estimates of excess cancer deaths associated with exposure to coal carbonization products. Note that the annual risk of death from cancer of the lung in both studies is approximately 1.5×10^{-3}. Numbers such as these result from careful studies of selected worker populations. Figure 12 shows similar information for male coal miners as compared with all workers in the United States for 1930 and 1950. The death rate in 1930 was 900 per 100,000 workers when all occupations are included; whereas that for coal miners was 1,300 per 100,000 workers.

Some work environments are hazardous from a safety standpoint instead of, or in addition to, a hygiene standpoint. Figure 13 gives information on industrial accident fatality rates for the United Kingdom in 1975. For all forms of employment, the death rate is about 50 deaths per million workers per year, or about 5 per 100,000. This annual risk of 5 per 100,000 is about the same as that annual risk of death in the U.S. in 1975 from peptic ulcer or congenital abnormalities as shown earlier.

In Figures 14 and 15 fatal accident rates in the United Kingdom according to occupation groupings range from 3 to 162 per million workers per year for the years between 1960 and 1972. The chemical and allied industries, metal manufacturing, ship building, and marine engineering represent the highest occupational fatality rates of all the U.K. workers studied.

An example of a very high occupational mortality rate is that for Louisiana oil workers is given in Figure 16. For all U.S. workers in 1978, mortality rate was about 14 per 100,000 workers. For U.S.

ESTIMATES OF EXCESS CANCER DEATHS ASSOCIATED WITH EXPOSURE TO COAL CARBONIZATION PRODUCTS

STUDY	CANCER SITE	EXCESS CANCER DEATHS PER 10^5 PERSONS PER YEAR	ANNUAL RISK OF CANCER DEATH
DOLL et al.*	LUNG	160	1.6×10^{-3}
GAS WORKERS	BLADDER	23	2.3×10^{-4}
	SCROTUM AND SKIN	12	1.2×10^{-4}
KAWAI et al.** OCCUPATIONAL LUNG CANCER	LUNG	119	1.2×10^{-3}

*BRITISH JOURNAL INDUSTRIAL MEDICINE *29*:394–406, 1972.
**ARCHIVES ENVIRONMENTAL HEALTH *14*:859–864, 1976.

Figure 11

DEATH RATES FOR ALL MALE WORKERS AND COAL MINERS*

USA, MALE, AGES 15–64, 1930 AND 1950, PER 10^5 WORKERS

YEAR	ALL WORKERS	COAL MINERS
1930+	900	1300
1950++	810	1480

*MODIFIED FROM M. A. SCHNEIDERMAN IN ERDA SYMPOSIUM SERIES NO. 39, 1976

+U.S. CENSUS – DATA FROM 10 STATES

++U.S.P.H.S.

Figure 12

INDUSTRIAL ACCIDENT FATALITY RATES
- UNITED KINGDOM*-

- Accidental death at work accounts for 5-6% of all fatal accidents.
- For men aged 15-65, 25% of all fatal accidents occur at work.
- For all forms of employments, rate is about 50 deaths per million workers per year.
- Rates dropped only by about 0.5% per year, on the average, for period 1959-1970.

*Data from Chief Inspector of Factories
Pochin, British Medical Bulletin, 1975

Figure 13

FATAL ACCIDENT RATES IN UNITED KINGDOM ACCORDING TO OCCUPATIONAL GROUP* (I)

OCCUPATION OR MANUFACTURE	DEATHS PER MILLION PER YEAR MEAN ± S. E.**
CLOTHING AND FOOT-WEAR	3 ± 1
ENGINEERING AND ELECTRICAL	23 ± 1
TEXTILES	23 ± 1
VEHICLES	26 ± 2
PAPER, PRINTING AND PUBLISHING	28 ± 2
METAL GOODS	29 ± 2

*POCHIN, BRITISH MEDICAL BULLETIN, 1975.
**12 YEAR MEANS (1960–1972).

Figure 14

FATAL ACCIDENT RATES IN UNITED KINGDOM ACCORDING TO OCCUPATIONAL GROUP* (II)

OCCUPATION OR MANUFACTURE	DEATHS PER MILLION PER YEAR MEAN ± S.E.**
FOOD, DRINK AND TOBACCO	34 ± 2
LEATHER, LEATHER GOODS AND FUR	37 ± 8
BRICK, POTTERY, GLASS, CEMENT, etc.	75 ± 5
CHEMICALS AND ALLIED INDUSTRIES	87 ± 5
METAL MANUFACTURE	136 ± 5
SHIPBUILDING AND MARINE ENGINEERING	162 ± 8

*POCHIN, BRITISH MEDICAL BULLETIN, 1975.
**12 YEAR MEANS (1960–1972).

Figure 15

EXAMPLE OF VERY HIGH OCCUPATIONAL MORTALITY RATE FOR LOUISIANA OIL WORKERS

WORKER POPULATION	MORTALITY RATE/ 10^5 WORKERS
• ALL U. S. WORKERS (1978)	14
• U. S. CONSTRUCTION WORKERS (1978)	57
• LOUISIANA OIL RIG WORKERS (AVERAGE PER YEAR FOR PERIOD 1973–1978)	200*

*205 DEATHS BETWEEN JANUARY 1973 AND DECEMBER 1978. BASED ON WORKER POPULATION OF 15,000.

Figure 16

construction workers in 1978, the comparable value was 57 per 100,000 workers. However, the rate for oil rig workers in Louisiana represents about 200 deaths per 100,000 workers per year. This study was based on the analysis of 205 deaths occurring between January 1973 and December 1978. The worker population was approximately 15,000 individuals. Thus, one of the most hazardous occupations in the United States seems to be oil drilling and explorations. In fact, the 205 occupational deaths for this group of workers represented 19.3% of all occupational deaths in Louisiana during the period 1973-1978.

Figure 17 gives information on cancer mortality in U.S. counties with significant petroleum industries. This study was a survey of the cancer incidence in 39 petroleum industry counties during the period 1950-1969. About 50,000 workers were included in the study which included control counties matched for population density, education, income and percent urbanization, non-white population, and foreign parentage. The study concluded that male residents in the petroleum industry counties showed significantly higher rates for cancer of the lung, skin, nasal cavity, and sinuses as compared to males in counties with similar demographic characteristics. The study does not conclude that the petroleum industries were responsible for the observed increase of certain cancers among male residents of these counties. It did, however, suggest the need for additional work in this area.

Figure 18 gives another example of a study which appears to show a relationship between materials in the environment and cancer mortality. Multi-variant regression analyses indicated a statistically significant relation between cancer mortality rates in Louisiana and drinking water obtained from the Mississsippi River. The relation is true for total cancers, cancer of the urinary tract, and cancer of the gastro-intestinal tract. This study represents an example of how individuals in the general public might be affected by materials produced and released to the environment by human activity.

De Minimis Risk Concepts

Potentially harmful chemicals and materials in varying quantities and concentrations to which human subjects may be exposed either at a work place or in the general environment have been and always will be a part of our lives. Because of the myriad of chemicals and materials to which citizens are exposed every day and because of the time lag between exposure and effect, it is clear that we will not be able to provide quantitative or even qualitative information on effects from small exposure. To be prudent and conservative it is generally assumed that any health effect is linearly related to the quantity of the material or dose to which a person is exposed. Because it is extremely difficult, and in most cases virtually impossible, to accurately assess the degree of harm or detrimental effect for truly small exposure levels we have what I call the intercept problem. I refer to the area

CANCER MORTALITY IN U. S. COUNTIES WITH PETROLEUM INDUSTRIES

- SURVEY OF CANCER INCIDENCE IN 39 PETROLEUM INDUSTRY COUNTIES FROM 1950–1969
- ABOUT 50,000 WORKERS IN STUDY
- CONTROL COUNTIES MATCHED FOR POPULATION DENSITY, EDUCATION, INCOME AND PERCENT URBANIZATION, NONWHITE AND FOREIGN PERCENTAGE
- MALE RESIDENTS IN PETROLEUM INDUSTRY COUNTIES SHOWED SIGNIFICANTLY HIGHER RATES FOR CANCER OF THE LUNG, SKIN, NASAL CAVITY AND SINUSES AS COMPARED TO MALES IN COUNTIES WITH SIMILAR DEMOGRAPHIC CHARACTERISTICS

SCIENCE **198**: 51–53 (1977).

Figure 17

ORNL WS-13654

DRINKING WATER AND CANCER MORTALITY IN LOUISIANA

Figure 18

MULTIVARIANT REGRESSION ANALYSIS INDICATES A STATISTICALLY SIGNIFICANT RELATION BETWEEN CANCER MORTALITY RATES IN LOUISIANA AND DRINKING WATER OBTAINED FROM THE MISSISSIPPI RIVER. THIS IS TRUE FOR TOTAL CANCER, CANCER OF THE URINARY ORGANS, AND CANCER OF THE GASTROINTESTINAL TRACT.

SCIENCE **193**: 55–57 (1976).

in which the linear relationship attempts to give a value for a small effect for a small given dose. In the basence of better information, we assume the same dose response as results from higher exposures. Because we need the products associated with many materials, we will not be able to legislate (or for that matter control) zero releases to the environment. It thus becomes of critical importance that we learn to accept the de minimis concept, and by that I mean the quantity of material that might be present in amounts so minute as to be considered relatively harmless to man and his environment. Once we determine a de minimis value for a given material, we would be able to dispose of or release the material without any unique handling or precautions, or for that matter, regulatory considerations. The real problem, obviously, is how small is small enough.

Let me give one example of an approach to establishing a de minimis level from the field of ionizing radiation. Figure 19 shows the variation of the natural background radiation dose rate for the United States. This work, from the Oak Ridge Associated Universities, shows the number of millions of persons exposed to various dose rates. The average is about 130 millirems per year with a standard deviation from the mean of about 20 millirems per year. It is of interest that some of the standards set by regulatory agencies for emissions from nuclear reactors are within the range of the standard deviation of the background. Some people might feel comfortable with a de minimis value of 20 millirem per year, whereas others might argue for a de minimis value of 2 millirem per year. The point is that we have a means of identifying a fraction of the natural background radiation dose rate; that is, one standard deviation or some fraction of that standard deviation.

Figure 20 shows the general value for the risk of induced cancer from nuclear radiation. This is an attempt at developing a de minimis approach. The value of 10^{-4} cancers per rem (per person) is the value generally accepted by national and international organizations concerned with radiation protection. If we translate this risk of one in 10,000 (per person/rem), to a one-in-a-million risk per person, the resultant value is 0.01 rem or 10 millirems. The previous slide showed the standard deviation of the radiation dose equivalent from the background radiation in the United States to be about 20 millirems. Therefore, a 10^{-6} risk per person may be considered to be negligible as it can be related to a radiation dose equivalent; that is within the standard deviation of that radiation dose rate associated with the total natural background using a linear, non-threshold dose-response model.

If we can agree to some procedure whereby we can establish a de minimis risk for one technology (or parts thereof), we may be able to redirect national resources to obtain information from other technological developments so that we do not find ourselves in the position where we

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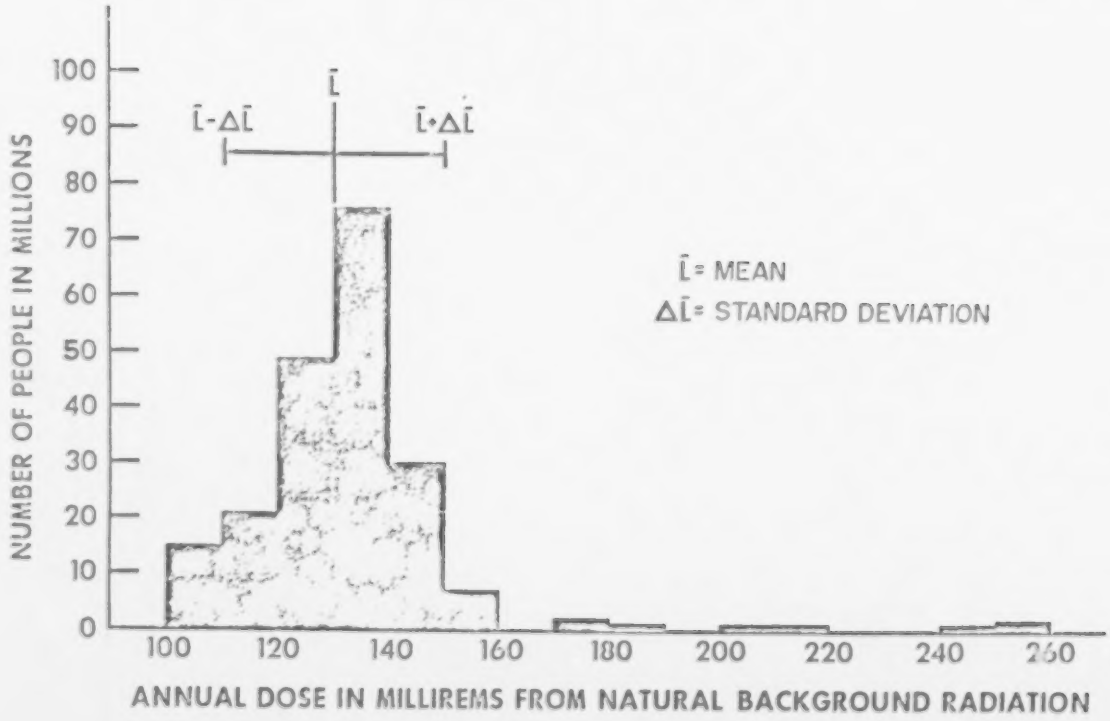

Figure 19

WHAT IS A REASONABLE OR NEGLIGIBLE RISK FOR PURPOSES OF RADIATION PROTECTION

- RADIATION INDUCED CANCER RISK

10^{-4} REM^{-1} · PERSON^{-1}

- RADIATION INDUCED CANCER RISK OF 10^{-6} PER PERSON

10^{-2} REM OR 10 MILLIREM

- STANDARD DEVIATION OF RADIATION DOSE-EQUIVALENT FROM NATURAL BACKGROUND IN USA

20 MILLIREM

- *PERHAPS* 10^{-6} PER PERSON RISK IS *NEGLIGIBLE* AS IT CAN BE RELATED TO A RADIATION DOSE-EQUIVALENT THAT IS WITHIN THE STANDARD DEVIATION OF THAT ASSOCIATED WITH TOTAL NATURAL BACKGROUND RADIATION USING A LINEAR NONTHRESHOLD DOSE-RESPONSE MODEL

Figure 20

know virtually nothing about the risk of one system as compared to our knowledge of the risks of an alternative or competing system. De minimis concentrations have been widely discussed in the nuclear area, perhaps because much is known about natural background concentrations and dose/effect relationships.

The summer of 1978 National Environmental Studies Project Report from the Atomic Industrial Forum discussed the question of de minimis concentrations of radionuclides in solid wastes. Conclusions to this study stated that a suggested appropriate level of protection to be used in establishing de minimis concentrations of materials containing trace amounts of radionuclides as a maximum total body dose of 1 millirem per year, or a maximum dose to any organ of 3 millirems per year to any individual. This level was suggested by the application of the 10-CFR Part 20 provision which allows one to ignore isotopic contributions which individually contribute less than 10% of the total dose and which collectively contribute less than 25% of the design level guides of 10-CFR Part 50, Appendix I. The concentration levels required to meet the suggested de minimis concentration were in the range of 1 picocurie per gram for important isotopes such as Cobalt-60 and Cesium-137. These concentrations are easily measured with normally accessible equipment at nuclear power stations. Incidentally, 1 picocurie per gram concentration level is similar to the concentrations of Radium-226, the naturally occurring alpha-emitting radionuclide in soils or in coal.

On July 11 of this year numerous individuals provided testimony to the newly formed Federal Radiation Policy Council. Several of these individuals argued for the development of de minimis levels for "low-level waste," especially as related to the nuclear medicine applications of radioactive materials. These individuals (representing organizations such as the Association of American Medical Colleges, the Association of American Universities, the National Association of State Universities and Land Grant Colleges, the American Hospital Association, the American College of Radiology, and the National Council on Radiation Protection and Measurements) argued that the definition of a de minimis level for low-level radioactive waste should be adopted by all Federal agencies and states with agreements with Federal agencies so that waste containing such de minimis levels could be incinerated, transported, buried, or stored locally without special regulations.

At similar hearings on August 5, 1980, in Atlanta other individuals also argued for the establishment of de minimis levels. For example, Dr. G. Eichholtz of the Georgia Institute of Technology pointed out that we are finding more and more situations where radiation exposure is only slightly above background levels, which raises the question of whether regulation is worth the cost.

The Environmental Protection Agency is also beginning to grapple with the question of de minimis levels. De minimis levels, a new component of the prevention of significant deterioriation (PSD) regulations will

accept the minimal additional emissions for small modifications in certain pollutants at new sources below which no (PSD) review would be required. The recently issued final rules set a 40-ton de minimis level for sulphur dioxide, nitrogen oxides, and ozone, and a 25-ton level for total suspended particulates and other levels for a group of non-criteria pollutants.

I think it is obvious that the adoption of de minimis criteria and concepts is an important and necessary scientific and technical undertaking. It is not clear, however, as to how we can most efficiently establish de minimis risk levels or concentration levels. Richard Atkinson, Chancellor of the University of California at San Diego and the ex-director of the National Science Foundation, has called for the establishment of a national commission to develop a concensus among all concerned parties on how environmental protection can best be pursued during the next two decades. The commission would provide a forum where both risks and costs could be examined in an open and thoughtful manner. Perhaps such a commission could advocate the need for de minimis criteria and levels in a non-biased manner. As Atkinson points out, "We have learned much about environmental protection in the last decade. It is time to apply that experience and knowledge to the continued improvement of public well-being."

Thank you.

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